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BUSINESS CYCLE PERSISTENCE IN CONTEMPORARY MACROECONOMICS

A literature review

Economics
Master's thesis
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Abstract of master's thesis

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Abstract

The recession that followed the financial crisis in 2007 has pushed many economies away from their pre-crisis growth trajectories. This questions the idea that short-term fluctuations in output, often called business cycles, and long-term economic growth are independent from each other. Empirical findings support the idea that these two phenomena are indeed not independent, indicating that business cycles tend to have persistent effects on long-term economic growth. However, in economic theory, there is no direct relationship between business cycles and long-term growth or it is vaguely defined. In many macroeconomics textbooks, short run and long run are studied separately with different models.

In more advanced models, such as the New Keynesian DSGE model used by most researchers on the topic, this link is also not explicit. However, there is literature that attempts to establish such a link or to explain the persistent effects of business cycles in general. In this master's thesis, I review this literature in order to construct an overview on how business cycle persistence is understood and modeled in contemporary economic theory. There are several explanations for business cycle persistence in macroeconomic theory and models. First, the existence of the zero lower bound on monetary policy and liquidity traps can have persistent effects on economic growth because the zero lower bound makes it possible to have two steady-state general equilibria in an economy simultaneously. One of these equilibria is often associated with a liquidity trap. Second, using the model of endogenous technological progress in macroeconomic models makes it possible to replicate the procyclical behavior in productivity growth often seen in real economies. This framework gives an explanation how short-term demand-side shocks can transform into medium-term supply-side shocks, which can decrease long-term growth potential. Third, according to the secular stagnation hypothesis, decreased long-term growth potential can also explain the recent persistence and lost output potential without linking short-term fluctuations and long-term growth. And finally, new methodologies in macroeconomic modeling, such as behavioristic decision-making rules, make models more consistent with the real economy and gives new insights for analyzing business cycle persistence. The apparent threat of business cycle persistence has also provoked some policy recommendations of rethinking monetary and fiscal policy, and regarding subsidizing R&D.

Keywords business cycles, recovery, recession, zero lower bound, monetary policy, stagnation, endogenous technological change, secular stagnation, New Keynesian model, macroeconomics, economic growth, potential output

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Tiivistelmä

Useat maat ovat edelleen jäljessä tuotannon tasoista, jotka ennustettiin ennen vuoden 2007 finanssikriisistä seurannutta maailmanlaajuista taantumaa. Tämä kehitys kyseenalaistaa vallitsevan ajatuksen siitä, että lyhytaikaiset heilahtelut tuotannossa ja pitkän aikavälin kasvupotentiaali ovat riippumattomia toisistaan. Empiiriset tulokset ovat osoittaneet, että nämä kaksi ilmiötä eivät ole toisistaan riippumattomia, mikä merkitsee sitä, että taloussuhdanteilla on vaikutus pitkän aikavälin talouskasvuun. Suhdanteilla ja pitkän aikavälin talouskasvulla ei ole suoraa yhteyttä talousteoriassa tai tämä yhteys on määritetty epäselvästi. Lyhyttä ja pitkää aikaväliä käsitelläänkin erikseen ja eri malleilla monissa makrotaloustieteen oppikirjoissa.

Edistyneemmissä malleissa, kuten uuskeynesiläisessä DSGE mallissa, jota suurin osa aiheen tutkijoista käyttää, tätä yhteyttä lyhyen ja pitkän aikavälin talouskasvun välillä ei ole myöskään määritetty eksplisiittisesti. Tätä yhteyttä ja taloussuhdanteiden pitkäaikaisia vaikutuksia on kuitenkin tutkittu kirjallisuudessa. Tässä maisterin tutkielmassa teen kirjallisuuskatsauksen rakentaakseni kokonaiskuvan siitä, miten nykyaikainen talousteoria ymmärtää, selittää ja mallintaa suhdanteiden pitkäaikaisia tai pysyviä vaikutuksia pitkän aikavälin talouskasvuun. Näille pitkäaikaisille vaikutuksille on löydetty useita selittäviä tekijöitä makrotalousteorialla ja makrotaloudellisilla malleilla. Ensiksi, rahapolitiikan nollakorkorajalla ja likviditeettiloukuilla voi olla pysyviä vaikutuksia pitkän aikavälin talouskasvuun, koska nollakorkoraja mahdollistaa sen, että taloudessa voi olla yhtä aikaa kaksi pitkän aikavälin tasapainotilaa. Toisessa näistä tasapainotiloista talous on usein likviditeettiloukussa. Toiseksi, teknologisen kehityksen mallintaminen endogeenisena muuttujana makrotaloudellisessa mallissa mahdollistaa sen, että tuottavuuden kasvu on taloussuhdanteen myötäistä, kuten se usein on oikeissa talouksissa. Tämä viitekehys antaa selityksen sille, miten lyhyen aikavälin kysyntäshokit voivat muuttua keskipitkän aikavälinen tarjontashokeiksi, mikä on omiaan vähentämään pitkän aikavälin tuotantopotentiaalia. Kolmanneksi, näennäinen suhdanteiden pysyvyys voi myös johtua yleisesti alentuneesta tuotantopotentiaalista, ainakin pysyvän stagnaation hypoteesin mukaan. Tämä tarkoittaa sitä, että globaali tuotantopotentiaali on voinut alentua suhdanteista riippumatta jo ennen finanssikriisiä. Myös uudet menetelmät makrotaloudellisessa mallinuksessa, kuten behavioristiset päätöksentekosäännöt, tekevät malleista yhdenmukaisempia oikeaan talouteen nähden sekä antavat uusia näkemyksiä taloussuhdanteiden pitkäaikaisuuden analysointiin. Näennäinen suhdanteiden pitkäaikaisuuden uhka on myös tuottanut joitain politiikkasuosituksia, kuten raha- ja finanssipolitiikan uudelleen ajattelemista ja tutkimus- ja kehitys –tukia.

Avainsanat taloussuhdanteet, talouden elpyminen, taantuma, nollakorkoraja, rahapolitiikka, stagnaatio, endogeeninen teknologinen kehitys, pysyvä stagnaatio, uuskeynesiläinen malli, makrotaloustiede, talouskasvu, potentiaalinen tuotanto

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1 Introduction

In many advanced economies, economic growth has not returned to its pre-crisis trajectory estimated on the eve of the global recession brought upon by the financial crisis in 2007. In addition to this persistent gap, estimates of output potential have been revised downwards frequently. This experience contests the idea that business cycles are only transitory deviations from a deterministic long-term growth path. Even though contested, this idea has been able to maintain its footprint on economics.

This framework of transitory business cycles is often on display, for example, in non-graduate economics education. The first time high school or undergraduate students hear about business cycles, they are usually shown a graph of output fluctuations over time, similar to Figure 1. In such a graph, there is a linear upward-sloping line representing the output trend and a wavy curve representing smooth and symmetric deviations of actual output around the aforementioned trend. When output is below the trend, there is a recession, and when output is above the trend, there is an expansion.

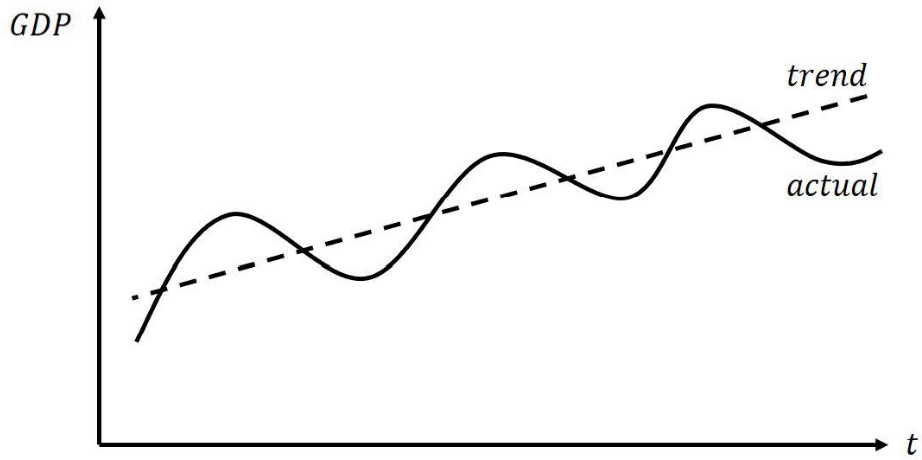

Figure 1: Business cycles in a simplified framework. Source: own work

This kind of thinking stems from the idea that short-term fluctuations in output or other economic activity are independent phenomena from long-term economic growth. In other words, this independence means that short-term fluctuations do not have an effect on long-term growth prospects. In the Solow growth model (Solow, 1956), long-term economic growth depends on growth in labor force, capital accumulation and technological progress. Short-term fluctuations might cause some high-frequency deviations in the aforementioned factors, but in the long run, these factors are assumed grow at stable rates. Since there has not been large-scale destruction of capital or labor force since the World Wars, these two factors have indeed been able to grow at a stable pace. In addition, post-World War II technological progress has been stable and rapid. Therefore, advanced economies have experienced high and stable growth rates in past decades.

If this simplified model of business cycles is the cognitive framework for decision-makers, such as politicians and firm executives, the slow recovery must seem disastrous. In many advanced economies, the pre-recession peak level in output was only reached recently after almost a decade of recovery, and some economies are yet to do so. Even the economies that recovered relatively quickly from the recession are still far below the potential output levels estimated before the recession. However, output gaps have become zero or positive in many countries recently, indicating that estimates of potential output must have been revised downwards after the financial crisis.

In economics, this has led to several research outputs studying some form of business cycle persistence. The extensive empirical literature on persistence of short-term fluctuations mostly affirms the hypothesis that recessions tend to have effects on long-term growth. Simultaneously, more theory-oriented literature has attempted to replicate the slow recovery and business cycle persistence using macroeconomic models. Bluntly speaking, the latter mentioned literature studies under which circumstances the independence of short-term fluctuations and long-term growth potential does not hold.

In this Master's thesis, I survey economics literature that attempts to explain why modern advanced economies might experience business cycle persistence in the light of economic theory. The overall aim is to provide a summary on how business cycle persistence is understood and which factors are causing it in contemporary macroeconomic theory and models. The literature usually employs some form of the dynamic general equilibrium model with different sets of equations and assumptions, while attempting to determine how and why short-term fluctuations might turn into persistent or permanent fluctuations in long-term economic growth.

There seems to be a few popular hypotheses regarding business cycle persistence in literature. First, the zero lower bound on monetary policy (hereinafter ZLB) can prevent normal adjustment of an economy to a shock. For example, after a large negative shock, stimulating the economy might require a negative real interest rate. If inflation is also low, the ZLB makes the central bank unable to provide this negative real interest rate, which can prolong the recovery from the shock. In addition, the ZLB can create an additional steady-state general equilibrium with low inflation, low growth and high unemployment. In this equilibrium, the economy is usually in a liquidity trap.

Second, the effect of short-term fluctuations on technological change can generate persistence in a prolonged downturn. For example, in the model of endogenous technological change, technological progress and thus the growth rate of productivity depends on profit-maximizing R&D activities done by firms. In a recession, firms' expectations of future profits decrease, which hinders R&D activities and other investments. Because of this, productivity growth decreases in a recession, which in turn decreases long-term growth potential. Therefore, it is possible that short-term fluctuations decrease long-term economic growth this way. In addition, endogenous technological change together with a binding ZLB can trap the economy in a low-growth steady-state equilibrium for a prolonged period.

Third, the apparent business cycle persistence might also reflect secular stagnation. According to the secular stagnation hypothesis, long-term growth potential has been steadily decreasing in previous decades because of several structural headwinds, such as adverse demographics and slowing innovation rates. However, these structural headwinds have been masked recently by the financial crisis, so it is difficult to say how much of the slow recovery can be accounted to business cycle persistence rather than secular stagnation. Anyways, it is possible that the recession has accelerated the ongoing process of decreasing output potential.

Finally, as opposed to the Great Depression and the stagflation in the 1970s, macroeconomics has not faced a drastic rethinking after the financial crisis (Krugman, 2018). After all, not being able to predict the crisis was not caused by a lack of understanding by economists but more by a lack of attention. Even though there has not been a revolution in macroeconomic thinking, there have been some insightful new developments recently. One of these developments is the incorporation of behavioral, empirically consistent decision-making rules for agents in macroeconomic models. As the agents become more myopic and less informed, they react less drastically to shocks, which can alleviate business cycle persistence. In addition, this low reactivity makes some forward-looking policies ineffective because agents put less weight on changes in long-term expectations.

To clarify to the scope of this thesis, I do not try to answer why the post-2007 recovery has been slow. For the sake of conciseness, I settle for reviewing work already done on this end to motivate the literature review on more theoretical work. In addition, I will not dig into the mathematical details of the findings and models used, even though there might be some benefits to this exercise. Therefore, to avoid unnecessary technicality, I review insights from literature more qualitatively and intuitively. Furthermore, the most used model in literature I review is a closed economy model. This can be seen as a minor caveat in the models especially regarding the applicability of the findings to local, geographically bounded recessions.

This thesis is structured as follows. First, I will briefly go through the some concepts that are used throughout this thesis. In Chapter 2, I briefly review some explanations for the post-2007 slow recovery especially in Europe and present some descriptive data on the recession and recovery. In Chapter 3, I overview how the field of economics understands business cycles and how this understanding has developed over time. In addition, I present the graphical 3-equation model by Carlin and Soskice (2005) both as an example of a modern textbook model and as a graphical framework for business cycle dynamics. In Chapter 4, I present the New Keynesian dynamic general equilibrium model by Christiano, Eichenbaum, and Evans (2005) as background information on the models used in the literature review. Chapter 5 is the literature review of the different explanations for business cycle persistence in contemporary macroeconomics, especially in the New Keynesian approach. Chapter 6 consists of policy recommendations that the reviewed literature provides for alleviating business cycle persistence. Chapter 7 concludes.

Concepts

- *Steady-state growth path*

  "Steady-state growth path" stands for the hypothetical future growth path in output that would occur with real interest rate and unemployment constantly at their "natural" levels and inflation at target. In other words, it is the medium-term equilibrium growth path in the absence of any short-term shocks.

- *Long-term growth potential*

  Partly synonymous to the previous term, long-term growth potential is more related to the expected levels in factors of long-term growth, such as population growth, technological progress and capital accumulation. Long-term growth potential has often been viewed independent from short-term fluctuations that are assumed to be only transitory. In short, steady-state growth path changes with shocks whereas long-term growth potential is not assumed to do so, unless the shock generates persistent changes in economic activity.

- *Short-term fluctuations*

  Short-term fluctuations are the deviations in economic activity from its hypothetical steady-state growth path in the absence of any shocks. In macroeconomics, it is often assumed that steady-state growth path is relatively smooth, and that actual output fluctuates above and below this path because of shocks.

- *Natural interest rate*

  The natural interest rate is the real interest rate that equates investments and savings with full employment in an economy. In other words, it is the steady-state real interest rate. In principle, the central bank would like to set its policy rate so that the actual real interest rate would equal the natural rate, thus keeping the economy in a steady state at all times.

- *Taylor rule*

  The Taylor rule is a form of monetary policy rule that an inflation-targeting central bank can follow to set a policy rate consistent with its inflation target. A simple form of this is:

$$i_t = \pi^T + r_t^* + \alpha(\pi_t - \pi^T) + \beta(y_t - y_e)$$

Following this rule, the nominal rate must be set according to the sum of the inflation target π^T and the natural interest rate r^*, and according to the deviation from the inflation target $\pi_t - \pi^T$ and the output gap $y_t - y_e$, with coefficients α and β. This rule can be either explicit or implicit.

- *Economic activity*

  I use "economic activity" as a parent term for output, employment and other variables that tend to fluctuate with business cycles. The reason for this is to avoid listing out all these variables repeatedly.

2 The slow recovery after the financial crisis

The phenomenon that has mostly motivated this thesis is the global slow recovery after the financial crisis in 2007. Output growth has stagnated and central banks have resorted to near-zero policy rates in an attempt to stimulate economic growth. While writing this thesis in the beginning of 2018, the global economy is showing signs of an upswing after almost a decade of recovery. However, especially in Europe, inflation continues to be low, and in some countries, economic activity stagnates below pre-crisis peak levels. Some governments have also accumulated large debts when trying to stimulate growth or to finance public services while facing decreasing tax revenues. Even though the economic outlook is not as gloomy as in the heat of the crisis, much uncertainty still revolves around the future.

In order to examine the recovery, it is necessary to define what a recovery actually is. After all, in public discussion business cycles usually consist of recessions and expansions only. In this view, an economy is in a recession when economic activity decreases and in an expansion when economic activity increases. However, there is a phase where the economy usually starts to grow gradually after a recession, as if to recover from the crisis. This business cycle phase is called the recovery phase, which begins when an economy starts to grow for the first time after a recession. The recovery is usually thought to end when economic activity returns to the pre-crisis level.

However, there are multiple definitions for "pre-crisis level" in business cycle literature. For example, it could mean that output returns to its pre-crisis peak level, output gap becomes zero, or output returns to its pre-crisis trend. The first definition is often used in empirical work (Reinhart & Rogoff, 2009; Fatás & Mihov, 2013) because of its simplicity. The second definition depends on the accuracy of the estimation of the potential output level in the economy. The third characterization is only valid if economic growth is expected to grow along a smooth trend in the long run.

Three alternative scenarios how an economy might recover from a recession in terms of output are presented in Figure 2. First, a recession can be followed by accelerated economic growth that shifts the economy back to its pre-recession growth path (the green line), indicated by the yellow curve. Second, output might recover back to its long-term trend growth rate but at a persistently lower output level because of the recession, indicated by the red line. Third, economic growth might recover to a lower long-term growth rate compared to the pre-recession rate, indicated by the blue line. In this scenario, long-term growth trend is decreased by the recession. According to Anttila (2016), the Euro area has most likely experienced the third scenario after the financial crisis.

Regardless of how a recovery is defined, the recovery from the financial crisis has been extraordinarily slow in comparison to earlier recessions. This is the finding of Fatás and Mihov (2013) in their study of the post-World War II recoveries in the United States. They study how the output gap and unemployment gap (the difference between “natural” and actual unemployment rate) have developed after post-World War II recessions, and how quickly output has reached its pre-recession peak level after these recessions . They also use an alternative econometric estimation method to identify cyclical components and recoveries. In all of their analyses, the most recent recession stands out as an outlier in terms of recovery speed, but not in terms recession depth. In Europe, the recovery has been even slower than in the United States, partly

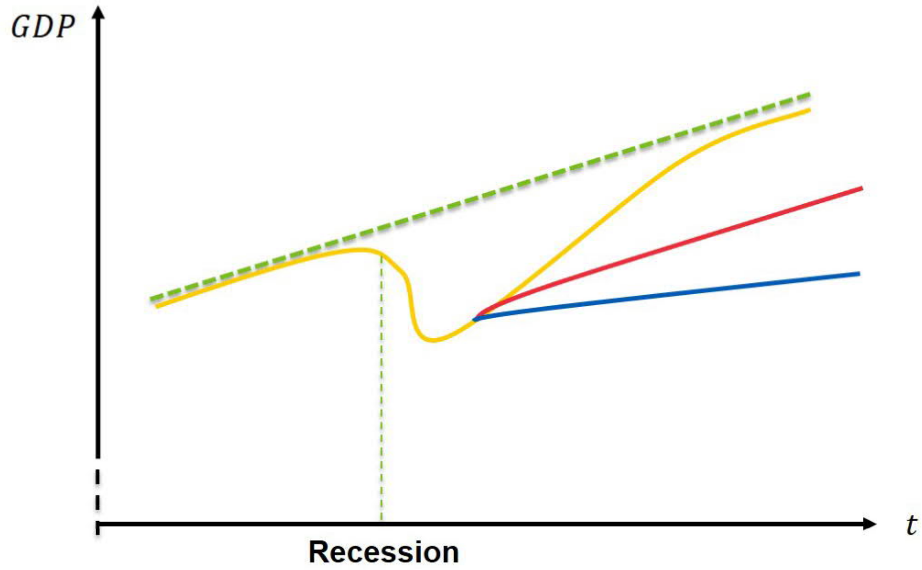

Figure 2: Recovery scenarios. Source: Anttila (2016) and own work

because of the sovereign debt crisis in 2012. Thus, the slow recovery is likely to be even worse problem in Europe.

In this chapter, I will examine the most recent business cycle in two ways. First, I briefly review explanations for the slow recovery from the financial crisis following Lo and Rogoff (2015). There are also many other insightful research outputs to this topic, but I will only focus on this one literature survey for the sake of conciseness. Second, I present data on key macroeconomic variables from the business cycle in Europe. The overall aim is to motivate the literature review in later chapters. My data analysis focuses on Europe because of the apparent business cycle persistence in the continent. I will also include the United States in the data in some parts for comparison, but for analysis on recoveries in the United States, one should turn to Fatás and Mihov (2013).

2.1 The slow recovery in literature

In their literature survey, Lo and Rogoff (2015) list theories about the slow recovery after the financial crisis. These include "a sustained lack of aggregate demand, slowing innovation, adverse demographics, lingering uncertainty, post-crisis political fractionalization, debt overhang, insufficient fiscal stimulus, and excessive financial regulation"

(Lo & Rogoff, 2015, p. 2). Their focus is not only on the United States, but on advanced economies as a whole. In this section, I will briefly overview the findings by Lo and Rogoff (2015).

One of the key messages of Lo and Rogoff (2015) is that the crisis has followed the pattern of earlier systemic financial crises. This argument is based on the work of Carmen Reinhart and Kenneth Rogoff, presented in depth in their 2009 book "This Time Is Different: Eight Centuries of Financial Folly" (Reinhart & Rogoff, 2009), where they analyze patterns in different types of economic crises using a large historical dataset.

The causes of the slow recovery in Lo and Rogoff (2015) can be summed up to three groups: decreased aggregate demand, decreased aggregate supply, and economic policies. First, the demand side of the economy has suffered from high leverage, persistent uncertainty, and structural headwinds. The first one can be interpreted as a normal characteristic of a business cycle: with financial distress and deteriorated expectations, economic agents will try to reduce their debt, which decreases aggregate demand. The uncertainty about the future caused by political and economic turbulence among other factors constrains demand for investments by both corporations and households. In addition to these two rather usual business cycle characteristics, aggregate demand is also pulled down by structural headwinds. The secular stagnation hypothesis argues that decreasing population growth and innovations, among other factors, are likely to decrease equilibrium growth rates in the future. This means that in the absence of unforeseeable positive shocks, there will be a permanent drop in aggregate demand.

Second, in the supply side, total productivity has been hurt by both cyclical and secular factors. An economic downturn is likely to reduce investments. This happens because firms' expectations about future profits deteriorate, which decreases present values of potential research projects, thus decelerating productivity growth in aggregate terms. In addition, increased financial regulation, tighter access to financial services, deteriorating human capital and lack of funds caused by corporate deleveraging are likely to hinder R&D projects further. Aggregate supply also suffers from structural headwinds as growth in labor force and education levels have slowed down. However, there are also countercyclical economic forces in productivity growth. According to some authors, a recession accelerates creative destruction that "cleanses" the economy of low-productivity firms.

Third, economic policies and legislation by governments have also played a role in the slow recovery. Similar to households and corporations, governments became indebted even before the financial crisis. After the crisis, stimulating fiscal policy was needed at the same time as automatic stabilizers decreased tax revenues. In order to have fiscal stimulus, debt levels continued to soar. Concerned about the increasing public debt, many governments resorted to fiscal consolidation, which prolonged the recovery. In addition to inadequate public spending, increased financial regulation, despite the apparent need for it, has also had a negative effect on the recovery.

2.2 The slow recovery in data

The slow recovery can also be seen in data, which complements the theories in the previous section. In order to provide a snapshot of the recovery, I present descriptive data from Europe and, in some occasions, the United States. The data has mostly been retrieved from the Macro-economic database AMECO constructed by the European Commission. To complement this data, I have also used data from Eurostat, OECD, U.S. Bureau of Economic Analysis and Bank for International Settlements. The data used is described in more detail in Appendix A.

In order to construct time series for the EU and the Euro area, I have combined the observations for different definitions of the two country aggregates. For example, in the case of the Euro area, I have combined the contemporary definitions for the area in recent decades to a single time series (not for absolute values, obviously). This can create some inaccuracy in the data, but this exercise makes it possible to analyze the country groups as a whole throughout time.

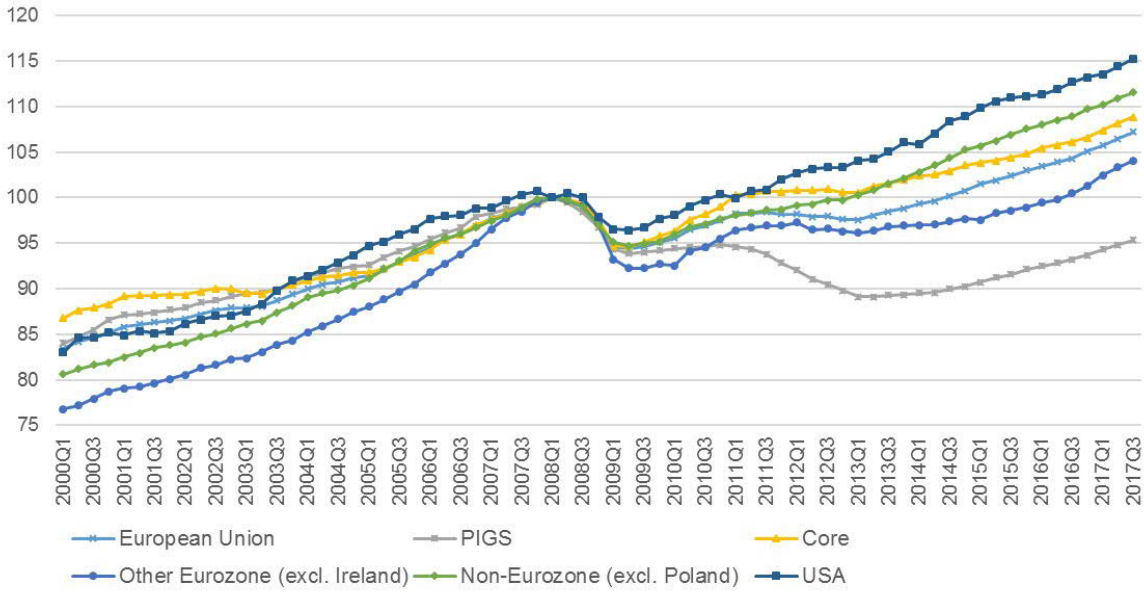

Figure 3: GDP, quarterly 1990-2017, index 2008Q1=100, seasonally and calendar adjusted data. Data source: European Commission (2018).

GDP and its components

The quarterly development of real Gross Domestic Product (GDP) for the EU, the United States and selected country groups in Europe can be seen in Figure 3 (groups defined in Appendix A). In the years before the recession, GDP growth was stable. When the financial crisis hit, it created a recession, which can be seen as a decrease in GDP levels between 2008-2010 in Figure 3. The following recovery has looked different between the observed areas: the United States recovered relatively quickly, whereas countries in the Euro area that suffered the most from the financial crisis and the sovereign debt crisis (the "PIGS") still lag behind the pre-recession peak levels in GDP.

Figure 4 shows average GDP growth rates in European country groups and in the United States before and after the recession. The pre-crisis trend is the growth trend from the first quarter of 2000 until the pre-crisis peak, which I have defined as the highest output level between 2007Q1 and 2008Q3. The post-trough trend is the trend from the lowest output level after the crisis until the third quarter of 2017. Unfortunately, the rates between Europe and the United States are somewhat incomparable because of the sovereign debt crisis. The key insight from Figure 4 is that growth rates have been lower after the recession than before it, meaning that catching up with

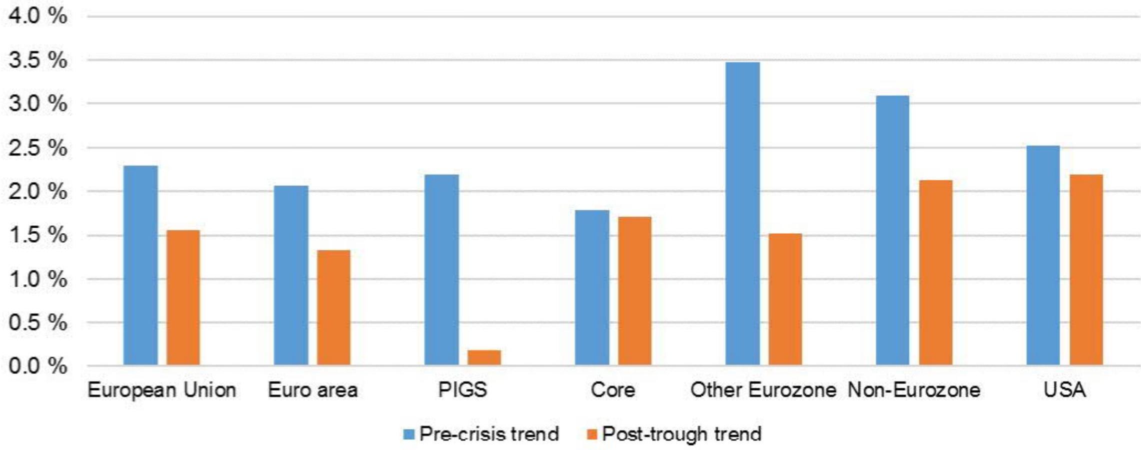

Figure 4: GDP growth trends before and after the financial crisis. Data source: Eurostat. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=namq_10_gdp&lang=en

the pre-recession trend in output has not occurred. However, the current post-trough trends do not seem that low, due to the current global economic upswing. But if the end point for the post-trough trend time interval is moved further to the past, such as 2014, the post-trough rates would be much lower.

The effect of the sovereign debt crisis and arguably some negative effects of the euro can also been seen in Figure 4. The highest drops in average growth rates have occurred inside the Euro area: in the PIGS countries and outside the core of the Euro area. Both of these areas have experienced 2 percentage points lower average growth rates after the recession than before it. The difference is less drastic in the United States or outside the Euro area in Europe.

In order to study how different components of GDP have affected growth rates in the EU, Figure 5 presents indexed time series for private and public consumption and for gross capital formation to reflect investments. The most noticeable feature of the figure is the pro-cyclical behavior of investments (approx. 20 per cent of GDP) and their apparent non-recovery the 2007 peak level. Private consumption (approx. 60 per cent of GDP) and public consumption (approx. 20 per cent of GDP) show stagnant yet stable post-crisis paths with increasing trends in most recent years. Interestingly, public consumption seems to be more pro-cyclical than countercyclical with no significant increase between 2010 and 2013, at the time when stimulating fiscal policy would have been needed the most.

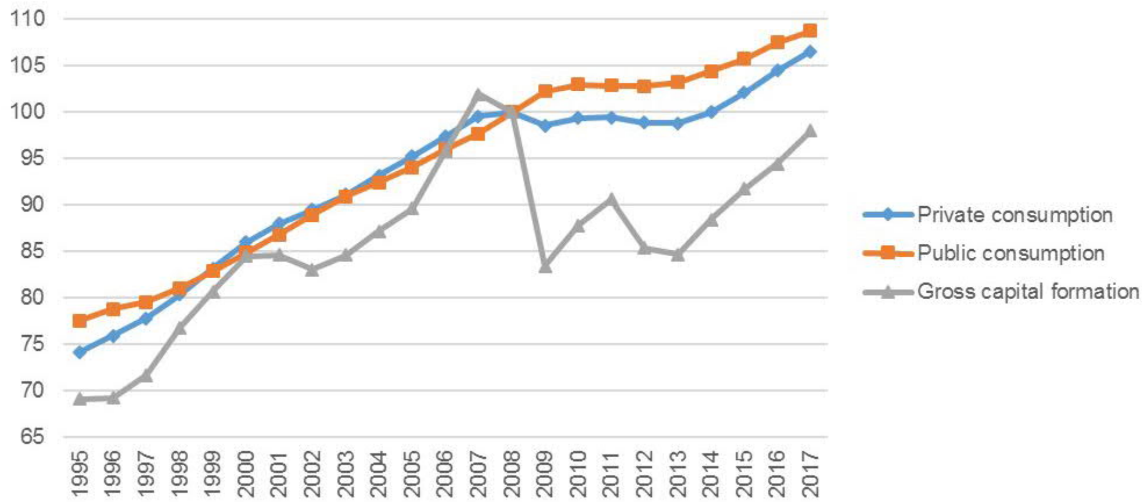

Figure 5: GDP components in the EU. Index 2008=100. Data source: European Commission (2018).

Output gap

Business cycles are often measured as fluctuations in the output gap, which means how much output deviates from its potential level each period. This potential output cannot be seen in data, so it must be estimated. This procedure is examined in more detail in Section 3.1.

The output gap in the EU-based estimation of potential output by European Commission (2018) is presented in Figure 6. The figure shows the two crises that European economies have faced as two separate dips in the output gap in recent years. However, it also seems that the output gap has closed again in 2017 because of the global economic upswing, meaning that the recovery is finally over in terms of output gap. Despite this positive observation, the zero output gap involves a negative aspect too, namely a decrease in potential output.

This is presented in Figure 7, where Italian output is used as an example. In estimates by European Commission (2018), Italian potential output has grown on nearly a linear trend between 1965 and 2008. However, after reaching the peak in 2008, potential output began to decline, with its current level equal to the 2005 level approximately.

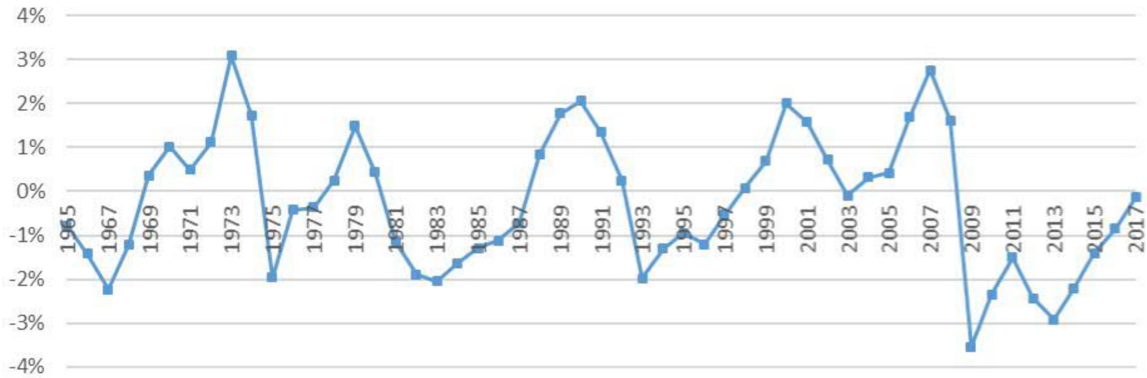

Figure 6: Output gap in the EU, % deviation from potential output. Data source: European Commission (2018).

Therefore, saying that the output gap has been closed does not mean that the economy has returned to its pre-crisis trend. Even though Italy represents a rather drastic example, other European economies also show decreasing trends in potential output growth. A reason for this might be that the long economic downturn has had persistent effects on long-term growth potential. As already mentioned, this is the phenomenon that has mostly motivated this thesis.

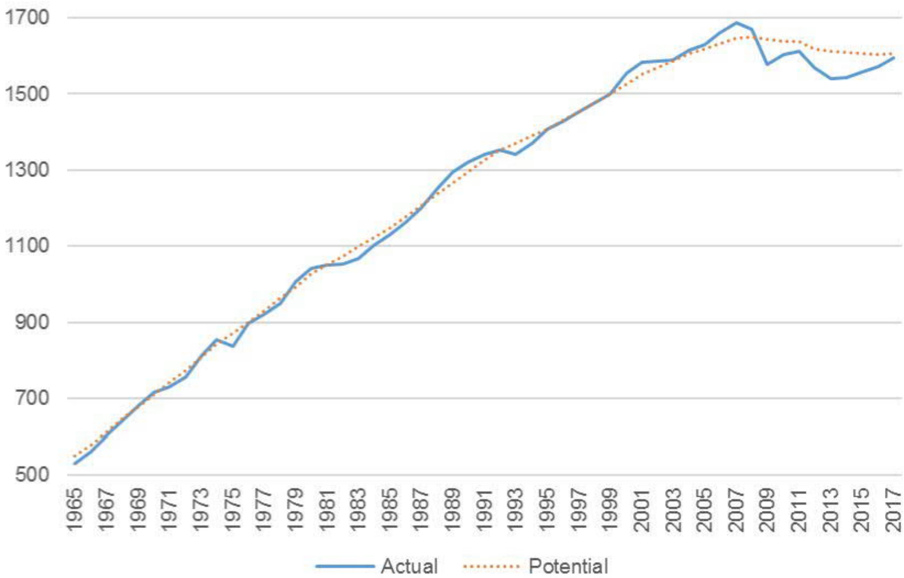

Figure 7: Actual and potential output in Italy, 1965-2017. Billions of euros. Data source: European Commission (2018).

Unemployment and inflation

Another factor of economic activity is the unemployment rate: the rate is often low during an expansion and high during a recession. The unemployment rate is also often linked to wage inflation: higher unemployment decelerates inflation, while low unemployment accelerates inflation because of increased bargaining power of workers. This relationship is consolidated in the Phillips curve, which is used as a building block of many macroeconomic models even though the relationship does not fully hold in data.

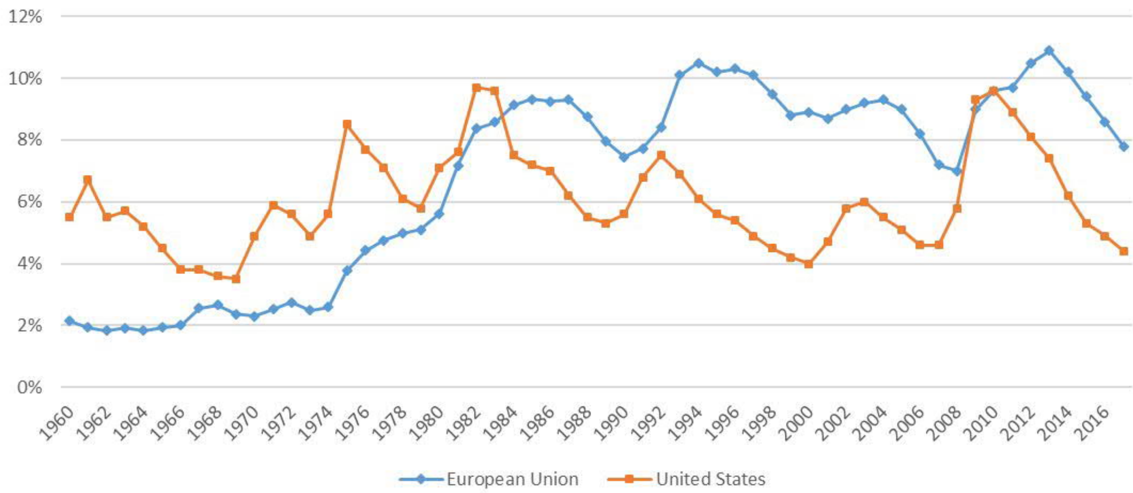

Figure 8: Unemployment in the EU and USA, %. Data source: European Commission (2018).

Figure 8 shows the time series for unemployment in the European Union and the United States. Regarding unemployment, the recent business cycle does not look in any way extraordinary. During the recession, unemployment was high but not abnormally high compared to historical levels. After the beginning of the recovery phase, unemployment has steadily decreased to its pre-recession levels. The sovereign debt crisis can be seen again as a difference in recovery phases between the EU and the United States. However, especially for the EU, the data hides large regional differences. In Spain and Greece, unemployment remains at very high levels, whereas unemployment in Germany is very low.

Interestingly, the relationship between unemployment and inflation has dampened after

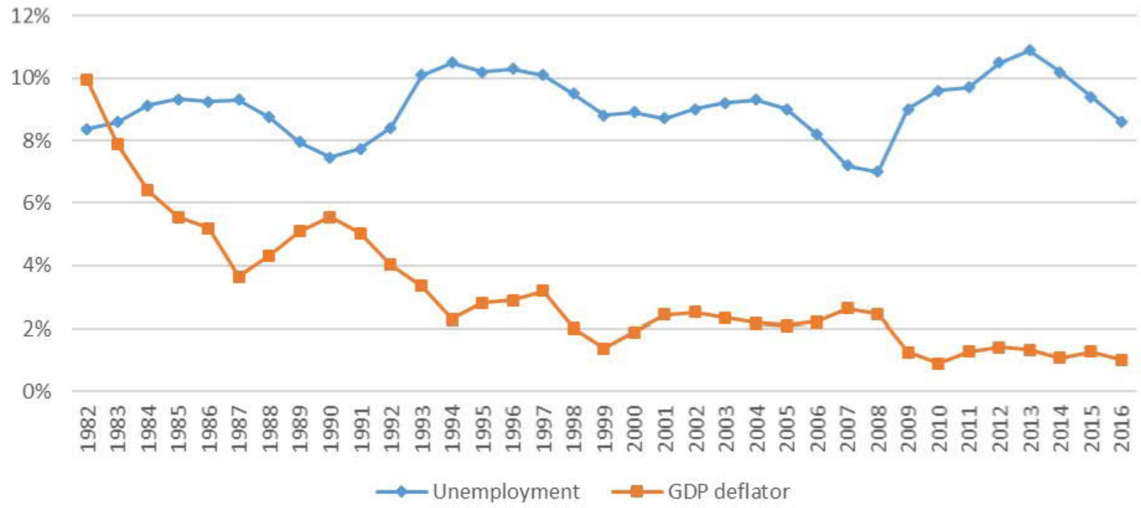

Figure 9: Unemployment and inflation in the EU, %. Data source: European Commission (2018).

the turn of the millenium. This is shown in Figure 9. As seen in the figure, there seems to be a strong negative correlation between unemployment and inflation before the year 2000. However, this correlation seems to be weak after the financial crisis: fluctuations in unemployment are not reflected in inflation rate as largely as before, if at all. This does not look like an effect of the slow recovery, but more like a continuous decrease in the inflation rate that has been going on for a long time.

Interest rates and monetary policy

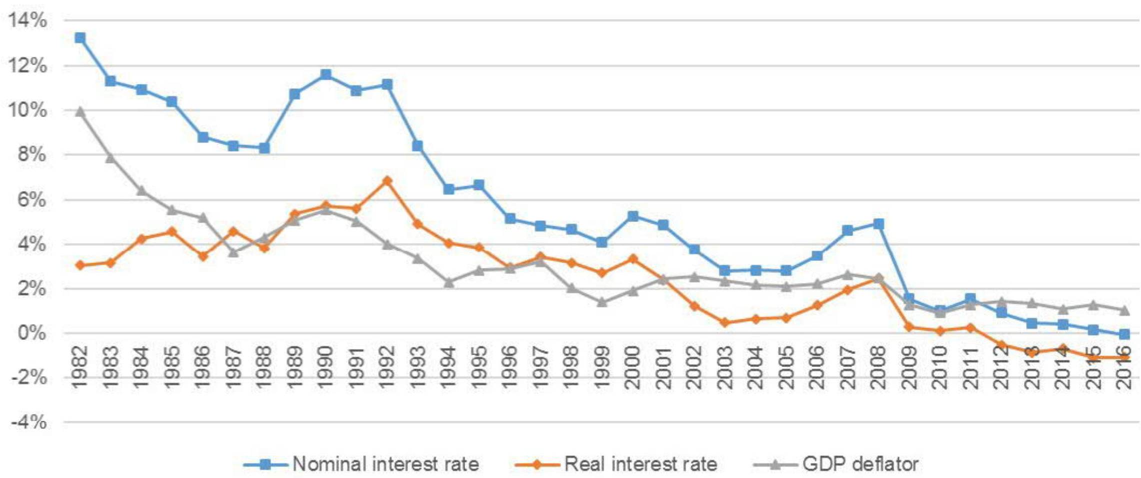

Figure 10: Nominal interest rate, inflation and real interest rate in the EU. Data source: European Commission (2018).

Figure 10 shows how nominal and real interest rates and inflation have developed in the EU since 1982. A direct observation is that all the rates have decreased towards zero at a stable pace. After the financial crisis, the real interest rate has been zero or negative in the EU, nominal rates have been approaching zero and inflation is below its 2 % target. Regardless of why the rates have been so low, low inflation and a potential need for a negative real interest rate to stimulate the economy have pushed monetary policy to the ZLB. This means that, in principle, when the policy rate reaches zero, the central bank does not want to decrease it any further, even though it could. The ZLB and related phenomena as sources of business cycle persistence are reviewed in Section 5.1.

The ZLB phenomenon can be seen in Figure 11. In the US, UK and the Euro area central bank policy rates have fluctuated between slightly negative rates and 1 % since 2009. Interestingly, there seems to be a difference in the reactions to the financial crisis between Euro area and the US and UK. The latter decreased policy rates close to zero in the beginning of 2009 and the rate stayed at that same low level for years. On the contrary, the ECB reacted less strongly to the initial shock and reached a constant level close to zero only around 2014.

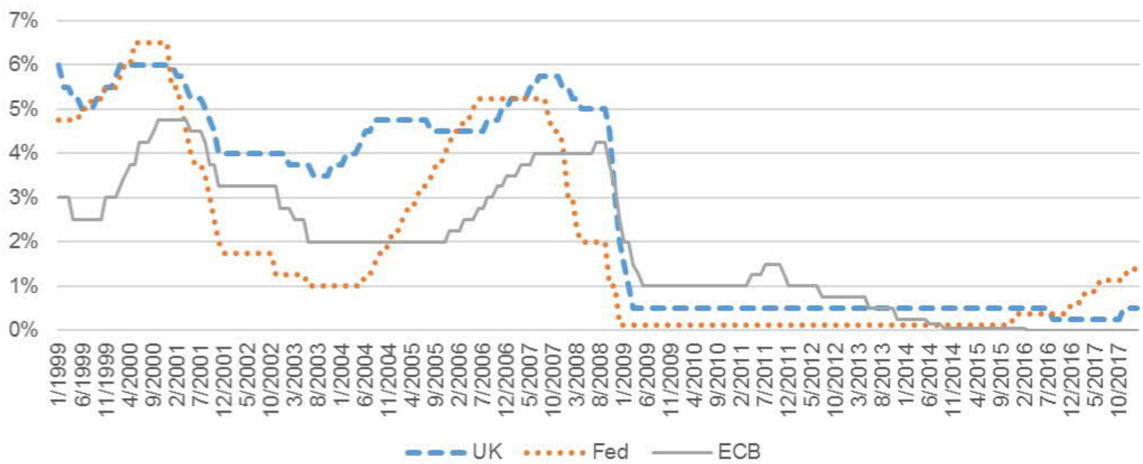

Figure 11: Central bank policy rates in the Euro area (ECB), the United States (Fed) and the United Kingdom (UK). Annual rates. Monthly data. Data source: Bank for International Settlements.

Debt

Especially when monetary policy is bounded by the ZLB, fiscal policy becomes the only conventional policy tool for stabilizing the economy. However, as seen in Figure 5, growth in public consumption was relatively flat during the first years of 2010s. One reason for this is that governments resorted to fiscal consolidation after the crisis when facing increased public debt levels. This increase in debt levels in shown in Figure 12. Some authors, such as Fatás and Summers (2017), argue that the consequent lack of countercyclical fiscal policies was one of the main drivers behind the slow recovery.

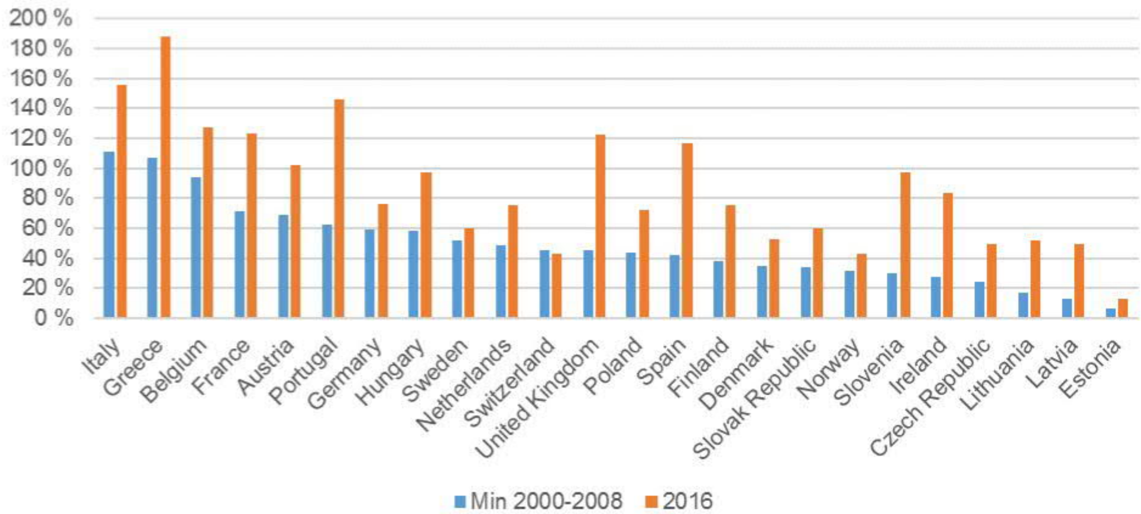

Figure 12: Debt-to-GDP ratios in Europe before and after the financial crisis,%. Data source: OECD. https://data.oecd.org/gga/general-government-debt.htm

According to this data, public debt levels increased significantly in roughly a decade. This development, and the Stability and Growth Pact signed by EU countries, in which countries agreed upon a public debt ceiling of 60 %, encouraged governments to begin fiscal consolidation as the economy was only recovering from the recession.

3 Business cycles in macroeconomic theory

Business cycles have been a topic of interest for economists for a long time. As Zarnowitz (1985) puts it, interest in the topic has evolved in a pattern similar to real-life business cycles: interest increases with economic turbulence but decreases with economic stability. After the Great Depression, the Keynesian macroeconomics became a permanent part of business cycle research. Nowadays, after the financial crisis and the following slow recovery, the topic has again gained relevance.

Zarnowitz (1985) surveys the theories of business cycles in a historical perspective. In the beginning of the 20th century, famous economists such as Knut Wicksell, Arthur Pigou, and Joseph Schumpeter among others studied the cyclical nature of the economy and the effects of real and monetary factors to this cyclical behavior (Zarnowitz, 1985, p. 17-18). At that time, most authors saw business cycles mostly as endogenous phenomena, meaning that business cycles were generated by internal dynamics of the economic system, not by some exogenous shocks. However, they noted that exogenous factors act as "originators" of the endogenous processes (Zarnowitz, 1985, p. 19). Frisch (1933) was one of the first ones to build a coherent model for business cycle analysis. His model includes erratic shocks that generate business cycles. The work by Frisch (1933) has been an inspiration especially to the Real Business Cycle (hereinafter RBC) approach, which is studied in Section 3.2.

Keynes emphasized uncertainty as a source of these endogenous cyclical fluctuations. In his framework, optimism spreads across the economy and capital prices increase in a boom. Once doubts about future profitability are aroused, they spread rapidly and reveal the true nature of many investments whose profitability relied on the optimistic expectations. As pessimism spreads, demand for money increases, which increases interest rates, aggravating the crisis. Only an economic downswing can bring the interest rate down to revive investments eventually (Zarnowitz, 1985, p. 21-23).

After World War II, inflation and growth rates remained persistently high, shifting attention away from Keynesian "economics of depression" and from business cycle research in general. However, the debate about the source of cyclical fluctuations continued. In recent decades, two schools of thought have emerged: the Real Business Cycle approach and the New Keynesian approach. In the former, real factors, such as production technology, are emphasized as determinants of business cycles. In the latter, nominal rigidities and monetary factors are emphasized over real factors.

In the remainder of this chapter, I will review contemporary theory around business cycles. First, however, in order to do so, I recap how business cycles are measured or how they should be. Second, I present the New Keynesian and Real Business Cycle approaches. Third, I present the 3-equation model by Carlin and Soskice (2005) and its cyclical dynamics to give a snapshot of how the economy responds to short-term fluctuations.

3.1 Measuring business cycles

Business cycles can be measured as increases and decreases in the level of economic activity. However, a more delicate measure for business cycles is the output gap, which is the difference between potential and actual output in a given period. Even though the output gap is a better measure of business cycles than output levels, it is not an accurate measure because potential output has to be estimated. In theory, potential output reflects an output level consistent with the natural interest rate. As Blanchard (2018) puts it, it is the level of output that would occur if, given actual history, all rigidities in prices and wages were lifted from now on.

According to Galí (2002), in empirical applications, output gaps are measured as deviations from a smooth trend obtained from the GDP series that is considered to reflect potential output. This smoothed trend can be obtained with some statistical tool, such as the Hodrick-Prescott filter. The Hodrick-Prescott filter removes cyclical components from a time series, and is thus able to produce a non-linear long-term trend for output. However, there is no theoretical reason why this smoothed trend should reflect potential output, unless one assumes that output would grow following a smooth path in the absence of any short-term fluctuations and rigidities. Despite this, the statistical methods are often used because they are an easy way to identify cyclical changes in a time series.

Alternatively, potential output can be estimated based on some estimation that tries to catch the long-term growth potential of an economy. Some institutions, such as the Congressional Budget Office in the United States and the European Commission, do their own estimates of potential output levels by estimating a production function for the economy and analyzing changes in the production function's variables to determine how potential output will develop (see Shackleton et al. (2018) for an example). This approach can be seen as more consistent theoretically but it does not mean that the estimation is free from uncertainty.

As opposed to the idea that actual output fluctuates above and below its potential equilibrium level, the "plucking model" by Milton Friedman (Friedman, 1993) defines potential output as a maximum level of output that could be obtained with current resources and technologies at each period. However, this maximum level is seldom reached because there are constant negative shocks hitting the economy. These shocks act as "plucks", as if actual output is glued to the bottom of the maximum level and someone is constantly plucking the line from different spots below. In this framework, business cycles can be interpreted as distance from the hypothetical maximum, or in other words, as the size of the negative shocks the economy is facing. However, like the potential output, estimations of the hypothetical maximum output are also vulnerable to uncertainty. Therefore, it cannot be said if one method is more accurate than the other in measuring business cycles.

3.2 The New Keynesian and Real Business Cycle approaches

Several sources, such as Galí (2002), Carlin and Soskice (2005), and Blanchard (2009) state that the contemporary business cycle research has been dominated by the New Keynesian (NK) and Real Business Cycle (RBC) approaches since the 1970s. Both approaches stem from the Lucas critique, which discouraged using macroeconomic models that rely on historical data on the estimation of crucial parameters because of the importance of expectations (Carlin & Soskice, 2005, p. 136-137). In addition, using only past data to estimate the effects of current policy changes generates biased estimations because people's behavior is likely to change with the policy. This critique gave a spark for restructuring macroeconomic models to incorporate microeconomic foundations: forward-looking, utility-maximizing agents, profit maximizing firms and so on. A key change in the models was the increased focus on agents' expectations of the future and the role of these expectations in agents' decision making.

Following the description by Carlin and Soskice (2005, Chapter 16), despite many built-in similarities, the NK and RBC approaches have some disputes about business cycle dynamics. In the RBC approach, researchers using this model have attempted to explain the cyclical components of GDP series smoothed with the Hodrick-Prescott filter as described earlier. In this approach, cyclical fluctuations occur because of exogenous technology shocks that affect the supply side of the economy, which affects interest rates and wages. The main adaptation mechanism is the households' response to these shocks regarding spending and employment decisions. This means that households adjust their consumption, working hours and saving rates in response to changes in interest rates, prices and wages, so that output shifts to its new equilibrium level consistent with the renewed production function. The smoothness in business cycles, as opposed to sharp jumps, is caused by persistence in the technology shocks: the shocks are assumed to die out gradually. The RBC model was built in a top-down fashion from the simple Solow model for long-term growth, leaving quite strong assumptions to the models, such as flexible prices and wages. Because of the absence of any rigidities in price-setting or wage-setting, fluctuations in output are always first-best outcomes. Given this conclusion, monetary and fiscal policies are deemed unnecessary in stabilizing the growth path of the economy.

In the RBC approach, the focus in explaining business cycles nests in the supply side of the economy. In the NK approach, the economy experiences shocks somewhat similarly but cyclical fluctuations do not occur because of persistence in the shocks: they occur because of nominal rigidities that make, for example, prices, wages, and consumption patterns rigid in the short run. This generates inertia in shock responses, thus allowing short-term shocks to transform into medium-term business cycles. In this approach, the economy is hit by, for example, monetary, technology or policy shocks. The shocks lead to instant responses by some agents, but not by all because of built-in rigidities in the model. This response is done, for example, with Calvo-style wage setting and price setting (Calvo, 1983), where agents face a constant probability of less than one of being able to re-optimize their decisions each period, leading to lags in shock responses. For example, a firm might be able to adjust its prices only three periods after a shock instead of an instant response.

As in the RBC approach, households change their consumption and employment levels after the shock in the NK approach. However, price-setters and wage-setters do not react as quickly as consumers do in their decisions. This means that economic activity drifts away from its equilibrium level because, for example, prices and wages remain too high after a negative shock in order to provide enough consumption to secure full employment. Therefore, shocks can affect growth in the medium run in the NK approach. As price-setters adjust to the shock over time, economic activity gradually returns to its equilibrium level. However, shocks can push the economic away from the pre-shock growth path as, for example, consumption changes in a different manner than if prices and wages were fully flexible.

One key difference in the results that the models yield is that stabilizing economic policy is efficient in the NK approach but not in the RBC approach. The intuition behind this difference is simple. In the RBC model, all outcomes are first-best because of price and wage flexibility, full information and rational expectations. Therefore, an economic policy authority cannot improve the outcomes. On the contrary, in the NK approach, outcomes are first-best given the rigidities in place. However, stabilizing policy can improve the outcomes if it can change shock reactions to better replicate the decisions that would be undertaken in a fully flexible economy. For example, if a shock would require a 2 % price decrease, but only half of the price-setters are able to re-optimize their prices, the overall price level decreases only by 1 %. If the central bank can make the re-optimizers decrease their prices by more than 2 %, the overall target of a 2 % price decrease becomes closer. This is a very simplified example but it shows the role for stabilization policy in the NK approach.

Regardless of the differences, the approaches have a common basis in understanding business cycles: more or less randomly arriving shocks shift the economy away from its previous growth path. Households and firms react to the shock by changing prices, wages, consumption, savings or some other factor. This affects inflation and interest rate, leading to gradual return to the steady-state growth path. The return is slower in the NK approach because of discrete price adjustments instead of flexible ones. In addition, the central bank plays a role in the adaptation in the NK approach.

3.3 The 3-equation model and business cycles

In his review of the state of macroeconomics as a whole, Blanchard (2009) states that the joint beliefs of economists on output fluctuations can be presented in three broad relations: an aggregate demand relation, a Phillips curve-like relation and a monetary policy relation. In the first one, output is determined by demand, which is in turn determined by expectations of future output and inflation. In the second relation, inflation depends on output and expected inflation and in the third relation, monetary policy is able to affect the real interest rate, thus affecting the two aforementioned relationships.

A textbook model following these relations has been formulated by Carlin and Soskice (2005). The authors present a macroeconomic model that incorporates three central equations: the Phillips curve (PC), the IS curve for demand and a monetary policy rule (MR) that the central bank follows (Carlin & Soskice, 2005). According to the authors, the model is a simplified version of the NK model used in DSGE models by policy makers, with some distinctive differences. Without taking a stance on whether the model is better than the NK models used by policymakers, the model is a useful tool for representing macroeconomic dynamics.

In order to introduce the model and its business cycle dynamics, I present the model both mathematically and graphically. The aforementioned three equations in the model are defined as follows:

$$\begin{aligned}
IS &: y = k(c_0 + a_0 + G) - ka_1 r_{t-1} \\
PC &: \pi_t = \pi_t^E + \alpha(y_t - y_e) \\
MR &: y_t - y_e = -\alpha\beta(\pi_t - \pi^T)
\end{aligned}$$

In the IS equation, y stands for output, k stands for fiscal multiplier, c_0 for autonomous consumption (in contrast to consumption that varies with income and taxes), a_0 for expected future post-tax profits, G for government spending, a_1 for the interest rate sensitivity of investment and r for the real interest rate. In the PC equation, π_t stands for current inflation rate, π_t^E for expected current inflation rate, $y_t - y_e$ for the output gap and α is a parameter that reflects the slope of the underlying wage-setting curve. The π^T and β in the MR equation stand for central bank's inflation target and relative weight of inflation deviations in central bank's loss function, respectively.

The curves derived from these equations are set to two different graphs for graphical analysis: the IS curve represents a negative relationship between the real interest rate (r) and output (y) in one graph, and the PC curve represents a positive relationship between inflation rate (π) and output (y) while the MR curve represents a negative relationship between them in another graph. Macroeconomic dynamics are represented as interactions between these three curves in the model.

The model is presented in its graphical form in Figure 13. The dynamics of the model can be explained using a temporary positive demand shock as an example. Given that the economy is at the long-term equilibrium (point a) at period zero, the shock shifts the IS curve to the right for one period from IS_1 to IS_2. Output expands from Y_e to Y_0, and the inflation rate exceeds the central bank's inflation target ($\pi_0 > \pi^T$). Period one equilibrium consists of points b. In the inflation-output graph, the economy is not on the MR curve. The central bank predicts the move in the Phillips curve for the next period (PC_2) by estimating expected inflation for the current period, and increases the nominal interest rate from r^* to r_0 by setting a higher policy rate. It does this in order to achieve a real interest rate consistent with the forecasted Phillips curve, the last period IS_1 curve (as aggregate demand rebounds back from the temporary shock) and the MR curve. This point leads to an interest rate above and output level below their long-term equilibrium levels in the first period after the shock, presented by points c. For the consequent periods, the central bank follows this same procedure: it forecasts the next period Phillips curve and sets the nominal interest so that output level (from the point on IS curve consistent with the real interest rate) corresponds to the intersection between the Phillips curve and the MR curve. This process goes on until the central bank reaches its inflation target. This process occurs gradually because agents react to changes in interest rates with a lag.

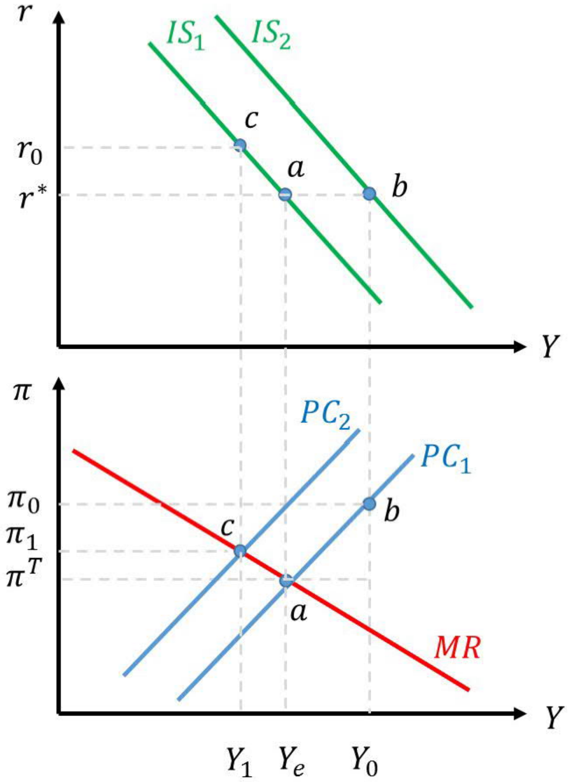

Figure 13: 3-equation model by Carlin and Soskice (2005, p. 91).

What does the 3-equation model say about the debate between the RBC and NK approaches regarding what drives business cycles? Given that the economy is in steady-state equilibrium (r^*, π^T, y^e, see Figure 13), only a shock that shifts any of the three curves can generate business cycles. Demand shocks shift the IS curve, supply shocks shift the PC curve and changes in monetary policy shift the MR curve. However, the model treats these shocks as exogenous and random, making the model fit for presenting past business cycles, but not for estimating potential correlations in movements of the curves. Overall, the model resembles largely the popular NK models.

4 The New Keynesian model

The main tool used in the literature reviewed in this thesis is the New Keynesian (NK) dynamic stochastic general equilibrium (DSGE) model. The model usually consists of households, firms and an inflation-targeting central bank as in the 3-equation model. These parties interact over time in markets, making the model dynamic. The stochastic components are often different stochastic shocks incorporated to the model that generate random shocks to technology, expectations and other crucial factors that affect agents' decision-making. Given the optimization rules and stochastic shocks, the model calculates a general equilibrium for every period.

The model is considered New Keynesian because it usually includes some explicit rules on how agents are or are not able to adjust to a shock. As described earlier, these rules can be rigidities in price setting, wage setting and consumption habits, for example. The inertia in reactions caused by these rigidities make adjustment to a shock slower than it would be in an economy with perfectly flexible prices and wages, which leads to cyclical fluctuations in output.

A key feature of the NK DSGE model is that because of the dynamic nature of the model, agents make decisions based on their expectations of the future every period. This means that agents do not only exercise one-period optimization, but they optimize their long-term utilities. For example, households understand that consuming more today could mean lower consumption in the future, forcing the agents to compare their marginal utilities for consumption and saving. Therefore, modeling agents' expectations in a certain way can have large effects on the outcomes of the model. For simplicity, expectations are often modeled as rational, meaning that, given full information of the underlying model, agents are able to form first-best rational expectations.

In the remainder of this chapter, I will overview the dynamic general equilibrium model by Christiano et al. (2005) in order to give a cross-section of a New Keynesian model used in most of the literature reviewed. The model I present does not include stochastic shocks often included in models used in applied work. Familiarizing oneself with the model is not essential in understanding the rest of this thesis but it gives good background information of the models used for those who are interested. I have chosen the model in hand for two reasons: first, it has served as a starting point for many DSGE models used worldwide (such as Smets and Wouters, 2007), and second, it is relatively easy and simultaneously extensive representation of the NK approach. I have chosen a model that does not include stochastic shocks for the sake of simplicity, but if the reader is interested in such models, the model by Smets and Wouters (2007) is a good example.

Firms

There are two kinds of firms: final-good firms and intermediate-goods firms. The final-good producer operates in a perfectly competitive market and thus acts as a price-taker. The intermediate-good producer is a monopolist who sells her goods to the final-goods producers. However, the market power of the monopolist is constrained by other intermediate-good producers who produce close substitutes to the monopolist's product.

At time t, the final-good producer produces a final consumption good Y_t by combining a continuum of intermediate goods $j \in [0, 1]$ using the technology:

$$Y_t = \left(\int_0^1 Y_{jt}^{1/\lambda_f} dj \right) \tag{1}$$

where λ_f is a constant $(1 \leq \lambda_f < \infty)$ and Y_{jt} is the input of intermediate good j at time t. As the firm takes output and input prices as given, profit maximization implies the Euler equation:

$$\left(\frac{P_t}{P_{jt}} \right)^{\lambda_f/(\lambda_f - 1)} = \frac{Y_{jt}}{Y_t} \tag{2}$$

Combining equations 1 and 2 gives a relationship between the prices of the final and intermediate good:

$$P_t = \left[\int_0^1 P_{jt}^{1/(1-\lambda_f)} dj \right]^{1-\lambda_f} \tag{3}$$

The intermediate-good monopolist uses capital k and labor L to produce the intermediate good with the technology (following a Cobb-Douglas function):

$$Y_jt = \begin{cases} k_{jt}^{\alpha} L_{jt}^{1-\alpha} - \phi & \text{if } k_{jt}^{\alpha} L_{jt}^{1-\alpha} > \phi \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

Where α is a constant ($0 < \alpha < 1$) and ϕ is the fixed cost of production. Assuming that there is no entry or exit to or from the market of good j, the monopolist will remain a monopolist. The monopolist rents capital and labor from perfectly competitive factor markets, meaning that they cannot affect the factor prices. Profits of the firm are distributed to households (who own the firm) at the end of each period. Workers must be paid in advance and the firm has to borrow the wage bill from a financial intermediary at the beginning of each period. As a result of optimization, the marginal cost s_t of the firm is:

$$s_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} (r_t^k)^{\alpha} (w_t R_t)^{1-\alpha} \tag{5}$$

Where R_t is the gross interest rate, r_t^k is the real rental rate of capital ($r_t^k = R_t^k / P_t$, where R_t^k is the nominal rental rate of capital) and w_t is real wage W_t/P_t. The firms execute Calvo-price setting: in every period, firms can re-optimize their price with a probability of $1-\xi$ ($0 < \xi < 1$). Given this probability, if the firm is able to re-optimize its price, it does so at the beginning of the period. The firms that are not able to adjust their prices regarding the probability just index their price to lagged inflation rate:

$$P_{jt} = \pi_{t-1} P_{j,t-1} \tag{6}$$

$\tilde{P}_t$ denotes the value of P_{jt} set by a firm that is able to re-optimize its price at period t. Note that only intermediate good producers are able to set prices themselves. A representative intermediate-goods producer then chooses $\tilde{P}_t$ to maximize:

$$E_{t-1} \sum_{t=0}^{\infty} (\beta\xi)^l v_{t+l} (\tilde{P}_t X_{tl} - s_{t+l} P_{t+l}) Y_{j,t+l} \tag{7}$$

Subject to equations 2, 5 and:

$$X_{tl} = \begin{cases} \pi_t \times \pi_{t+1} \times \cdots \times \pi_{t+l-1} & \text{for } l \geq 1 \\ 1 & \text{for } l = 0 \end{cases} \tag{8}$$

v_t is the marginal value of a dollar to a household, E_{t-1} is the expectations operator conditioned on lagged growth rate of money and l is sort of a time operator. The time operator runs from zero to infinity thus summing the expected future profits weighted by the probability for each period of not being able to re-optimize the price ξ. The X_{tl} coefficient adds the future inflation adjustments to the price $\tilde{P}_t$, following equation 8. β is a constant.

Households

There is a continuum of households, indexed by $j \in [0, 1]$. The j^{th} household first decides upon how much capital it allocates to consumption and saving (capital services to supply). Second, it decides how many securities to buy. Third, it sets a wage rate that it offers to the labor market. However, there is a similar probability ξ that the household cannot re-optimize the wage rate, as was the case in price setting. Fourth, the household receives a lump-sum transfer from the monetary authority. Finally, it decides how to allocate its remaining assets between cash and deposits. Introducing such a sequence to the model is important because the decision have impacts on each other, thus making it challenging to solve all decisions simultaneously in the model.

The inability of re-optimizing the wage rate causes heterogeneity among the agents regarding their wages. However, the authors argue that households are homogeneous regarding consumption and asset holdings, but heterogeneous regarding wages and hours worked, which means that those who have higher salaries work less in this model. The preferences of the household are given by:

$$E_{t-1}^{j} \sum_{l=0}^{\infty} \beta^{l-t} [u(c_{t+l} - bc_{t+l-1}) - z(h_{j,t+l}) + v(q_{t+l})] \tag{9}$$

The functions $u(x)$, $z(x)$ and $v(x)$ represent different functional forms for different utility functions. c stands for consumption, b for a habit formation parameter, which is another factor that causes rigidity in the model. h stands for hours worked and q stands for real cash balances (nominal amount of cash Q_t divided by price level P_t).

The household's asset evolution from one period to another (M_t to M_{t+1}) is given by:

$$\begin{aligned} M_{t+1} =& R_t[M_t - Q_t + (\mu_t - 1)M_t^a] + A_{j,t} + Q_t + W_{j,t}h_{j,t} \\ &+ R_t^k u_t \bar{k}_t + D_t - P_t[i_t + c_t + a(u_t)\bar{k}_t] \end{aligned} \tag{10}$$

where $W_{j,t}h_{j,t}$ is labor income, μ_t is gross growth rate of per capita stock of money, $(\mu - 1)M_t^a$ is the lump-sum payment from the monetary authority that the household receives. $\bar{k}_t$, D_t and A_t are, respectively, the household's physical stock of capital, firm profits and net cash inflow from security markets. u_t is the utilization rate of capital. The term $a(u)\bar{k}_t$ is the cost to households of having a utilization rate of u from function $a(x)$.

Given (12), the households stock of physical capital k_t evolves according to:

$$\bar{k}_{t+1} = (1-\delta)\bar{k}_t + F(i_t, i_{t-1}) \tag{11}$$

where δ the physical rate of depreciation: it denotes purchases of investment goods. The function $F(x)$ stands for technology that transfers current and past investments to future capital.

The wage decision

The demand curve for labor h_{jt} by household j is:

$$L_t = \left(\frac{W_t}{W_{jt}}\right)^{\lambda_w/(\lambda_w - 1)} L_t. \quad 1 \leq \lambda_w < \infty \tag{12}$$

where W_t is the aggregate wage rate and L_t is aggregate labor supply, both of which an individual household takes as given. Households are able to re-optimize their nominal wages in a similar way that firms are able to set their prices: with a probability $1-\xi$ the household can re-optimize the wage and with probability ξ it cannot. If the household cannot re-optimize, the wage follows lagged inflation as price did in equation 6.

Monetary policy

The authors assume that monetary policy is given by:

$$\mu_t = \mu + \theta_0 \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} \dots \tag{13}$$

The θ_j reflects a response to a monetary policy shock at time t to an expected monetary policy shock $E_t \mu_{t+j}$.

My aim in this section was not to present a usable and detailed model, but more to give a cross-section of a model that is used in the literature reviewed in the chapters to come. The results often depend on the dynamic adjustments that the model creates after a shock, which means that changing the underlying model and its assumptions can change the model's results significantly.

5 Business cycle persistence in New Keynesian economics

The anatomy of a business cycle in modern economies can be expressed quite simply verbally. During a boom, economic growth accelerates because economic agents, including consumers, firms and governments, believe that the fast growth will continue indefinitely, as argued by Reinhart and Rogoff (2009). These beliefs become optimistic despite the fact that booms always tend to end in a recession. The optimistic expectations caused by high growth rates lead to increased indebtedness of consumers, firms and government and thus to increased consumption by these agents.

Such a booming economy is vulnerable to negative shocks that force agents to revise their expectations downwards. Such a negative shock to expectations forces agents to adjust their consumption and debt levels downwards, which often brings upon a recession. One way that this shock impacts the economy in New Keynesian models, such as Christiano et al. (2005), is that households change their cash balances, which has an effect on the real interest rate and real variables when cash balances change.

Because booms and recessions follow this animal spirit-like behavior, these two phases are difficult to predict or prevent. However, these phases seem to be transitory by nature: an expansion often leads to an overheated economy and possibly to asset price bubbles prone to burst, and a recession is often a short-lived phenomenon because the economy is bound to grow in the long run because several agents actively fight to achieve growth in profits, incomes and other variables.

In addition to these two well-known phases of the business cycle, several authors (for example, Fatás and Mihov, 2013) also add a recovery phase as the third phase to business cycles. As consumers and firms are done with adjusting to new, lower expectations, output starts to recover gradually to its steady-state growth path determined by, for example, population growth, capital accumulation and labor productivity growth. However, the speed of this recovery is often uncertain. It might be that if stabilizing policies are absent, post-recession growth may stagnate for long periods, causing substantial losses in long-term welfare (at least hypothetically). As Fatás and Mihov (2013) estimate, the cost of a recession (cumulative "lost" output compared to trend) can be up to 20 per cent of the GDP in the pre-recession peak.

In literature regarding recoveries, there is extensive empirical evidence that recessions, especially caused by financial crises, have a negative effect on long-term growth potential of output. This evidence questions the idea that business cycles are only transitory deviations around a predetermined growth trend. A brief review of empirical evidence in this topic is found in Fatás and Summers (2017), which is partly summarized below.

In their estimation, Nelson and Plosser (1982) are unable to reject a hypothesis that the time series of U.S. GDP has a unit root. This implies that historically speaking, the U.S. GDP time series does not present a stationary deterministic trend, meaning that short-term deviations have actually had an effect on long-term output growth. Using an international sample, Campbell and Mankiw (1989) find that a one per cent shock to output should correspond to a one per cent revision in forecasted future output, which is consistent with the finding of a unit root by Nelson and Plosser (1982).

In recent literature, Cerra and Saxena (2008) use a large data set to show that the output losses from financial crises and some types of political crises are highly persistent. Studying OECD countries, Furceri and Mourougane (2012) suggest that a financial crisis affects potential output negatively and permanently. Reinhart and Rogoff (2014) compare recoveries of GDP to their pre-crisis peak levels from different financial crises and argue that financial crises cause deeper slumps in output and that financial crises accompanied by a slower recovery compared to other crises on average. Additionally, according to Fatás and Summers (2017), several authors have also shown that during a crisis, estimates on potential output are more than often revised downwards. This reflects the idea that a part of the pre-recession future output potential is lost permanently because of the recession.

Given this evidence, how has contemporary macroeconomic theory explained the persistent effects of short-term deviations in long-term growth potential? This is the question to be examined in this chapter. One potential explanation is either insufficient, unsound or incapable economic policy, especially monetary policy. Some authors have modeled how liquidity traps and the ZLB might force the economy to drift away from its pre-crisis trend. As expectations regarding future output, inflation, interest rate and profits are adjusted downwards, the real interest rate that would be consistent with full employment (or "natural" unemployment) can decrease below zero. This interest rate is often called the "natural" interest rate. Given that inflation is also low, monetary policy can hit the ZLB, meaning that the central bank would like to set a negative nominal interest rate because even a zero nominal interest rate is insufficient in reaching a real interest rate equal to the "natural" rate. However, the central bank is unwilling to set a negative nominal interest rate because if it did so, people would resort to cash because it brings a zero interest rate as an asset in principle. Therefore, at the ZLB, monetary policy becomes ineffective in stabilizing the economy. This might have effects on long-term growth potential.

To give another explanation, some authors have tried to establish a link in macroeconomic models between short-term fluctuations mostly caused by demand-side shocks and long-term growth potential that is mostly determined by supply-side factors. One way to do this is to model technological progress as an endogenous process done by profit-maximizing firms instead of determining it as an exogenous variable. This endogenous technological change amplifies the effects of the short-term fluctuations, especially if the economy is constrained by the ZLB, meaning that negative shocks to demand might hinder investments and research by firms. This can lead to decreased total factor productivity (hereinafter TFP) growth in the medium run and thus to decreased potential output in the long run. Other authors have also identified other channels through which temporary shocks might transform into a decrease in long-term growth potential, including prolonged unemployment or fiscal consolidation.

Another branch of recent literature around the apparent business cycle persistence focuses on the secular stagnation hypothesis. This literature puts more focus on the decreased long-term growth potential of the economy that has occurred regardless of the recent downturn or other short-term fluctuations. However, the secular stagnation hypothesis does not say that the short-term fluctuations have no effect on long-term growth potential, as shocks to demand often determine which steady-state equilibrium the economy will end into in models with multiple equilibria. Despite this, it is important to examine whether the experienced decrease in output potential after the crisis has been an effect of the slow recovery itself or just a symptom from some growth-constraining long-term developments.

Furthermore, some authors, such as Gabaix (2016), have focused on enhancing the building blocks of the New Keynesian DSGE model to achieve better real-life fit for the models. This work consists of editing the microeconomic foundations behind the model by, for example, introducing behavioristic decision-making rules for the agents in the model. This work of introducing irrationality, myopia and other real-world observations to the model gives fresh insights about the possible existence of business cycle persistence, especially as a permanent phenomenon.

In the remainder of this chapter, I will review literature that attempts to explain persistence in business cycles. First, I focus on the ZLB, liquidity traps and monetary policy in general as sources of persistence. Second, I examine how short-term fluctuations and long-term growth are linked in literature. The links I study are endogenous technological change and the hysteresis hypothesis. Third, I focus on secular stagnation and potential long-term headwinds that might be creating persistence in business cycles. Finally, I present how behavioristic modeling affects the ideas of business cycle persistence.

My focus will be mostly on New Keynesian (NK) literature and models for two reasons. First, most contemporary literature on the topic utilizes some version of the New Keynesian DSGE model. Second, a variation of the NK dynamic stochastic general equilibrium (DSGE) model has been used in recent years by important economic decision-makers, such as central banks, and by researchers. My aim is to analyze relevant theories, differences in these theories and results verbally in order not to focus excessively on the mathematical foundations of the models. To better visualize these theories, I present graphical representations of the models and results when feasible.

5.1 The ZLB, liquidity traps and multiple equilibria

If an economy hits the ZLB in a recession and falls into a liquidity trap, post-recession recovery might be slowed down, which can have negative effects on long-term economic growth. In the traditional IS-LM framework, in which the central bank uses money supply as a policy tool, a liquidity trap occurs when monetary policy becomes ineffective. This means that if the central bank increases money supply, real interest rates do not decrease when people prefer holding that extra money in cash instead of investing it in bonds because cash gives a better rate of return. If the central bank intended to depreciate the value of cash by increasing money supply, the attempt would not result in increased demand for bonds. Thus, monetary policy has become ineffective. If the central bank has an inflation target and it follows a Taylor rule, a similar problem occurs when the central bank would need to set a negative policy rate but it is unwilling to do so. This happens because people resort to cash because it provides a zero interest rate, while bonds provide a negative interest rate. These problems of liquidity traps and the ZLB are largely alike but technically somewhat different. Nevertheless, they are symptoms of the same problem in principle.

The concept of liquidity traps is nothing new, so its occurrence should not have been a surprise to economists after the financial crisis. According to Krugman (1998), the idea was introduced by John Hicks (Hicks, 1937) alongside with the IS-LM model. However, the idea had "[...] steadily receded both as a memory and as a subject of economic research" (Krugman, 1998, p. 137) because both inflation and nominal interest rates have been well above zero in the developed world after World War II, dampening the threat of falling into a liquidity trap. The idea was resurfaced by Krugman (1998) while studying the experience of the Japanese economy in 1990s of low interest rates, low inflation and stagnant growth. Currently, the theory of liquidity traps provides insights regarding the post-financial crisis recovery dynamics.

One common narrative in recent literature on the topic is that ineffective, inflation-targeting monetary policy, with the help of common economic dynamics, might create two or more steady-state general equilibria in an economy instead of having only one. The other equilibrium is often associated with detrimental outcomes, such as low growth, inflation and interest rates, and liquidity traps. Some authors see that this liquidity trap equilibrium, while being able to create a persistent slump in economic activity, is only a temporary phenomenon caused by a temporary drop in the natural interest rate (Benigno & Fornaro, 2016). This is the case in, for example, Krugman (1998): if the economy falls into a liquidity trap, price level adjusts to pessimistic expectations with deflation, eventually leading to a price level consistent with expectations and current money supply. Eggertsson and Woodford (2003) study a temporary drop of random length in the natural interest rate that leads to a liquidity trap. In their model, there is a positive probability that the natural interest rate becomes positive again after the initial shock, which gives a maximum length for the liquidity trap. Eggertsson and Krugman (2012) and Guerrieri and Lorenzoni (2017) study liquidity traps under financial shocks that lead to tighter access to credit, forcing indebted consumers and firms to adjust debt levels downwards. In these models, the economy exits the liquidity trap once the deleveraging is finished.

However, other (and partly the same) authors, such as Benigno and Fornaro (2016), have found that liquidity traps might become permanent in certain circumstances. In this case, an economy that is in a permanent liquidity trap might find itself in a low-inflation, low-growth steady-state general equilibrium instead of recovering back to the intended steady-state equilibrium consistent with the central bank's inflation target. In the remainder of this section, I will focus on the literature that studies liquidity traps and the associated multiple equilibria as permanent phenomena, partly following the summarization of permanent liquidity trap literature by Benigno and Fornaro (2016, p. 4). Nevertheless, the work on temporary liquidity traps is also valuable in understanding how recessions might have long-term effects.

In most models with a permanent liquidity trap, the force that pushes the economy to the unintended "bad" equilibrium is a large negative shock of some sort. If the economy is in the proximate neighborhood of the intended steady-state equilibrium with positive inflation and growth rates, a mild shock can usually be accommodated by standard monetary and fiscal policy. Therefore, it can be assumed that this equilibrium is at least locally stable. A shock that would lead to a permanent liquidity trap must thus be substantial. However, these shocks are not always presented in detail, especially in more simplified models, such as the IS-LM model and the 3-equation model by Carlin and Soskice (2005). The focus in textbooks and literature seems to be explaining how the economy reacts to shocks and adopts to them, not examining what these shocks actually are. Therefore, to understand how the economy might end up in a liquidity trap, I start with studying these shocks briefly. For further review on the topic of shocks in macroeconomics, one should turn to Ramey (2016).

The shocks presented in macroeconomics textbooks often involve policy shocks (monetary or fiscal), technology shocks or, for example, oil price shocks. These might be popular in textbooks because these shocks are easy to understand as concepts, they are mostly exogenous and they are important for policy work. However, the recent recession, for example, cannot be accredited to these conventional and exogenous shocks directly. In the benchmark NK DSGE model by Smets and Wouters (2007), the authors identify seven different structural shocks that drive business cycles. These shocks, which are modeled as stochastic processes, are presented in Table 1. In short, in their estimations, Smets and Wouters (2007) find that demand-side shocks (exogenous spending, risk premium and investment-specific technology shocks) account mostly for short-term fluctuations in output whereas supply-side shocks (wage and productivity shocks) account for output in the medium and long run.

Table 1: Different shocks in a DSGE model by Smets and Wouters (2007)

	A shock to
Productivity shocks	Total factor productivity
Intratemporal shocks	Risk premium
	Investment specific technology
Intertemporal shocks	Wages
	Prices
Policy shocks	Exogenous spending
	Monetary policy

In Smets and Wouters (2007) and other contemporary NK models, the non-policy shocks are often modeled as stochastic processes. This means that the shocks are random and exogenous by nature, and these random shocks generate business cycle-like fluctuations in economic activity.

The channels through which the shocks affect the economy vary between models. According to Guerrieri and Lorenzoni (2017), in representative agent models a liquidity trap is generated by a shock to intertemporal preferences that changes consumers' willingness to save, thus decreasing the natural interest rate. These shocks involve, for example, risk premium shocks (as in Smets and Wouters (2007)) that incentivize agents to save more and to favor less risky investments. In their own model with heterogeneous agents, the natural rate is pushed down by a shock to agents' borrowing capacity, leading to changes in loan demand and supply that decrease the natural interest rate. In addition to these shocks, in some models deflationary expectations become self-fulfilling, pushing the economy to a liquidity trap. In any case, the shocks affect the natural interest rate one way or the other.

Regardless of how the economy ends up in a liquidity trap, the main finding in literature is that falling into the liquidity trap can change the equilibrium growth path of the economy in the long run. This means that the liquidity trap, or the ZLB, might allow for a steady state "bad" equilibrium with low inflation, zero interest rate and low growth. Falling into such an equilibrium can make a recession extremely persistent or a recovery extremely slow, leading to large losses in potential output relative to the pre-crisis estimates.

The idea that the economy might not be characterized by a single stable steady-state equilibrium has been discussed even before the Great Recession, but the sluggish recovery has revived the topic again. As an example of the earlier work, Benhabib, Schmitt-Grohé, and Uribe (2001) present an idea how two steady-state general equilibria might exist in an economy where the Taylor rule -following central bank is bound by the ZLB. Their idea is presented in a simplified graph in Figure 14.

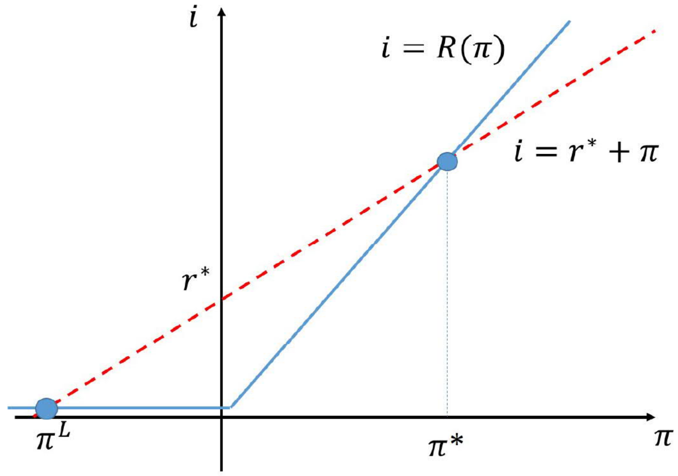

Figure 14: Real interest rate dynamics with an inflation-targeting central bank in Benhabib, Schmitt-Grohé, and Uribe (2001)

Following the Fisher equation, the steady-state nominal interest rate consists of the sum of natural (full-employment) real interest rate and inflation rate, presented by the dotted straight line $i = r^* + \pi$. Monetary policy is presented by the piecewise-linear function $i = R(\pi)$: when inflation increases above inflation target ($\pi > \pi^*$), the central bank increases (decreases) the nominal interest rate more than the increase (decrease) in inflation was ($R'(\pi) > 1$), meaning that the monetary policy curve is steeper than the steady-state rate curve in the positive quarter of the coordinate system. The intersection of the two upward-sloping curves presents the intended steady state at the inflation target. However, given that ZLB exists, the monetary policy curve becomes flat when the ZLB is reached. This is presented angle in the monetary policy curve near the origin. The important part in the authors' intuition is that when the ZLB is reached, monetary policy becomes passive ($R'(\pi) < 1$). Because the steady-state line is globally linear, the two curves must intersect at a second point with low inflation and zero nominal interest rate ($\pi^L, 0$). This point presents a steady-state general equilibrium because the policy rate is equal to the steady-state nominal rate, intended or not. At this point, the economy is in a liquidity trap with zero nominal interest rate and deflation.

However, Benhabib et al. (2001) do give intuition why either of these equilibria might be selected in the end. Their main argument is that if there is an active-policy steady state, there must also be a passive-policy steady state if monetary policy is bounded by the ZLB. This result is possible because the authors extend their analysis beyond the neighborhood of the intended steady state to account also for the ZLB. In the words of the authors, earlier literature has mostly focused on the proximate neighborhood of the inflation target, implicitly or explicitly assuming global linearity of the monetary policy rule. If global linearity is assumed, the intended steady state is globally unique because of the absence of the ZLB.

To study the dynamics of the multiple equilibria and the selection between them, Evans, Guse, and Honkapohja (2008) build on the work by Benhabib et al. (2001) by adding stochastic shocks and learning to the model. The shocks in their model are determined as stochastic and exogenous shocks that affect consumption and inflation expectations. They argue that "a large pessimistic shock to expectations" can push the economy to a short-term general equilibrium from which the economy does not converge back to the intended steady state. The non-converging equilibrium path can lead to deflationary spiral, namely a liquidity trap, under standard policies. Regarding multiple equilibria, they find results consistent with Benhabib et al. (2001): the intended equilibrium (at inflation target) is locally stable and achievable in normal times, but not globally unique. Evans et al. (2008) find that under standard policies, there are equilibrium paths that lead to a locally unstable steady state with low inflation. "Locally unstable" means that if expected inflation drops even slightly below the steady-state inflation rate, the equilibrium path might lead to a deflationary drift. For a visual representation of this, see Figure 1 in Evans et al. (2008, p. 11).

After the financial crisis, financial intermediation has been incorporated to macroeconomic models in order to understand and replicate the slow recovery. This makes it possible to involve debt and saving better into macroeconomic models. Eggertsson and Mehrotra (2014) are able to model a permanent or very persistent liquidity trap caused by a deleveraging shock in an overlapping generations-model. Their model builds on the secular stagnation hypothesis that argues that low or negative population growth, increasing inequality and an oversupply of savings, among other things, might make the natural interest rate permanently or persistently negative. Eggertsson and Mehrotra (2014) use this hypothesis and a deleveraging shock (similar to Eggertsson and Krugman, 2012) to cause a permanent decrease in the already low natural interest rate, pushing the economy to a permanent liquidity trap where the economy is permanently in the secular stagnation equilibrium.

To visualize their findings, Eggertsson and Mehrotra (2014) provide a graphical aggregate supply – aggregate demand (AS-AD) framework, presented in Figure 15. In short, both curves have different regimes depending on whether ZLB is binding or not. Given that there is no long-term trade-off in output and inflation, the AS curve is vertical in normal times because output is at its full-employment level: a change in inflation rate does not affect real wages nor marginal costs, keeping output constant in the long run. Because wages are fully downward rigid in the model, a negative inflation rate decreases aggregate supply because real wages increase, increasing firms' marginal costs. This leads to an upward-sloping AS curve when inflation is negative. The AD curve is downward-sloping as it usually is during normal times: a higher inflation rate leads to a more than one-for-one increase in the nominal interest rate (Taylor rule) and the real interest rate increases, causing a decrease in demand. When the ZLB binds, an increase in inflation rate leads to a decrease in real interest rate as nominal interest rate remains zero ($r = i - \pi$). This means that an increase in inflation leads to an increase in output (as real interest rate decreases), leading to an upward-sloping AD curve when the ZLB binds.

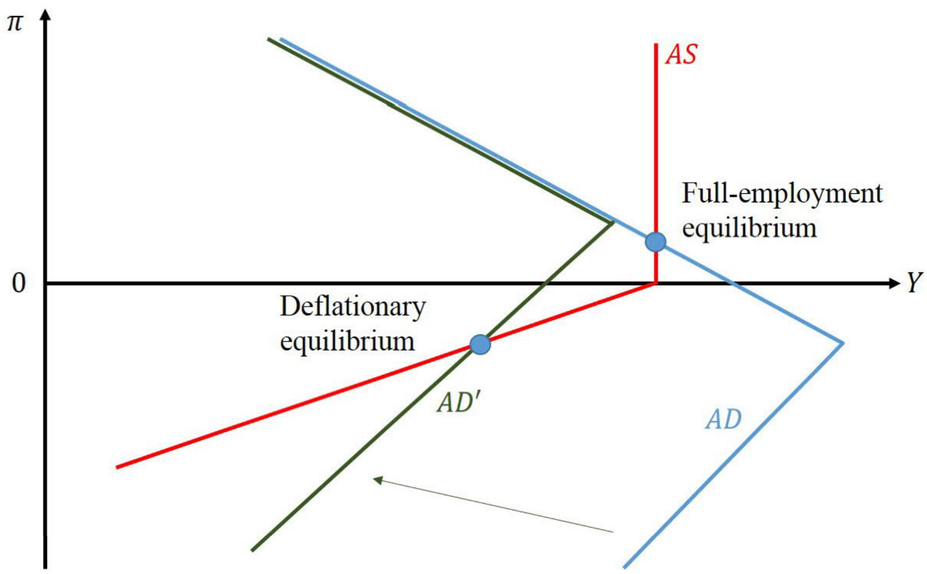

Figure 15: A model of secular stagnation by Eggertsson and Mehrotra (2014).

The kink in the AD curve represents the point where the ZLB first starts to bind: if natural interest rate is -2 %, and inflation is 2 %, the central bank would like to set the nominal interest rate at 0 %. In this case, the kink would be at 2 % inflation. If inflation was any lower, the central bank could not decrease the nominal interest rate, thus preventing the real interest rate from reaching its natural level.

In this AS-AD framework, a large enough negative shock can decrease the natural interest rate and shift the AD curve, pushing the economy to the deflationary equilibrium ($AD - AD'$). The shift happens because with a lower natural interest rate, the ZLB becomes binding earlier, moving the kink in the AD curve to the left, ceteris paribus. Given that there are no further shock-like movements in the curves, the deflationary equilibrium, or the secular stagnation equilibrium, is a steady state (a determinant equilibrium as mathematically proved by the authors), meaning that the liquidity trap becomes permanent. One point that the authors focus a lot on is that in this equilibrium, the traditional macroeconomic relationships become distorted. For example, if firms' marginal costs are exogenously decreased, AS curve shifts right. However, as opposed to normal times, this shift would lead to a decrease in output and inflation because of the inverted AD curve.

The persistence of the liquidity trap in this case seems to rely on the assumption by the secular stagnation hypothesis that the natural interest rate becomes indeed permanently negative. However, as the authors put it, their "purpose is to establish the conditions under which a permanent recession can take hold [...]" (Eggertsson & Mehrotra, 2014, p. 34). Eggertsson and Mehrotra (2014) find that the secular stagnation steady-state equilibrium is locally determinate (as opposed to Evans et al., 2008), so in the absence of large positive shocks or rethinking of policy, the liquidity trap is permanent. There seems to be no automatic mechanism that would increase the natural interest rate in the secular stagnation steady state.

In a similar way to Eggertsson and Mehrotra (2014), Carlin and Soskice (2018) visit the idea that the key relationships in traditional macroeconomic frameworks may become distorted when the ZLB binds. They study how the economy might have two steady-state general equilibria in their three-equation model ($IS-PC-MR$), which is already presented in Section 3.3. One of these equilibria is the "Wicksellian" good equilibrium, where inflation is at target and real interest rate is at its natural Wicksellian level. The other equilibrium is the "Keynesian" bad equilibrium, where the ZLB binds, inflation is zero, unemployment is high and real interest rate is higher than the natural rate. In their model, as in the literature already studied in this Section, the Keynesian equilibrium is just "a large negative shock" away from the Wicksellian equilibrium.

To achieve this result, Carlin and Soskice (2018) change some assumptions behind the Phillips curve in their textbook model. Instead of presenting a positive short-run relationship between inflation and output (as in the textbook), Carlin and Soskice (2018) assume that when inflation is positive, the long-run Phillips curve is a vertical line between employment and inflation, meaning that there is no long-term trade-off between inflation and unemployment. This is the same assumption that Eggertsson and Mehrotra (2014) have in their model (see Figure 15). However, if inflation is zero, the Phillips curve becomes a horizontal line over the horizontal axis. This is because the authors argue that there is in fact a zero floor on wage inflation based on the Japanese experience since the 1990s. This assumption is different from Eggertsson and

Mehrotra (2014) who have an upward-sloping AS curve when the ZLB binds.

The general dynamics behind the model of Carlin and Soskice (2018) are presented in Figure 16. The Wicksellian equilibrium is characterized by the curves IS_1, PC and MR_1, leading to an equilibrium consisting of real interest rate r^*, inflation at target π^T and employment at level n^W. This is the intended steady state. As in other models, short-term fluctuations are caused by exogenous shocks that primarily affect demand and the natural interest rate and thus the location of the IS curve. The natural interest rate can be seen as the point in the IS curve that is consistent with steady-state employment n^W. Therefore, there is a location for the IS curve, $\bar{IS}$, where the natural interest rate is zero, causing the Wicksellian equilibrium to occur at real interest rate of zero, inflation at π^T and nominal interest rate at $i = \pi^T$. If the IS curve were to shift further from this point, the Wicksellian equilibrium would become unachievable with a positive real interest rate.

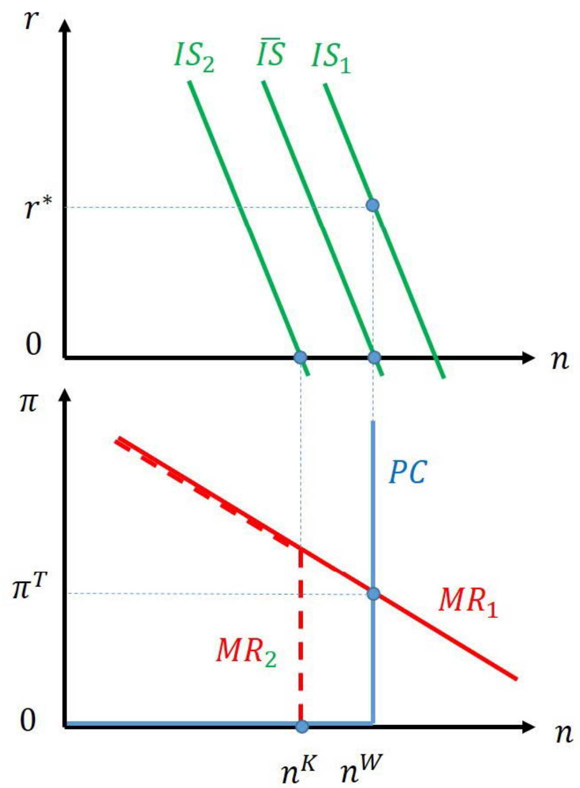

Figure 16: 3-equation model by Carlin and Soskice (2018)

If the exogenous shock is large enough to push the IS curve left from $\bar{IS}$, such as the curve IS_2, the natural interest rate becomes negative. Hypothetically, the central bank would like to set a negative nominal interest rate while having positive inflation, so that the real interest rate equal the natural interest rate. In a numerical example, this means that if the natural interest rate was -2 % and desired inflation rate was 1 %, the central bank would like to set a nominal rate equal to -1 % ($i = r + \pi$). However, the ZLB holds the central bank from doing so. The best it can do is to set a nominal interest rate of zero. Thus, monetary policy consistent with the IS_2 curve is presented as MR_2 curve. If wages were fully flexible, the economy would enter a deflationary spiral, as in other models in this section. However, because of the zero floor on wage inflation and the ZLB, agents expect inflation to be zero instead of negative in the future. Consequently, ceteris paribus, the economy ends up in the Keynesian equilibrium with zero real interest rate and inflation and high unemployment.

There is no automatic force in the model that could push the economy from the Keynesian equilibrium to the Wicksellian equilibrium. Low productivity growth (due to low investments), low aggregate demand and zero floor on wage inflation make the Keynesian equilibrium permanent. Carlin and Soskice (2018) also argue that increased uncertainty in labor markets could have affected the wage-setting relation so that the range of unemployment rates where the Keynesian equilibrium is possible becomes wider. However, fiscal policy or some other positive shock can push the economy

5.2 Endogenous technological change and hysteresis

The previous section focused on the idea that short-term shocks can push an economy towards a steady-state equilibrium with stagnating growth, high unemployment, low (zero) interest rate and low inflation. However, if these shocks would be equally likely to be either positive or negative (for example, following normal distribution with zero mean), the economy could escape the permanent liquidity trap on its own with an arbitrary positive shock. In addition, it is not too difficult to think of policy responses, such as a positive fiscal shock, that could alleviate the concerns of falling into a permanent liquidity trap.

If such a positive shock, random or calculated, can push the economy out of the liquidity trap, is the economy capable of returning to its pre-crisis output growth trend with little damage done? Empirical literature briefly surveyed in the beginning of this paper seems to answer "no". To build a connection between recessions and long-term growth potential, a branch of literature has established connections between the demand and supply sides that can transform short-term deviations into business cycle persistence. Campbell and Mankiw (1987) argue too that if output fluctuations can be persistent, more focus should be put on supply-side factors in explaining business cycle dynamics. Similar findings regarding different shocks were also developed by Smets and Wouters (2007) in their DSGE model, where they find from variation decomposition of their model that supply-side shocks do explain more of the deviations in long-term growth than demand-side shocks.

As opposed to having exogenous technology shocks in the RBC approach, the aforementioned branch of literature develops a connection between short-term demand-side shocks and medium-term supply-side shocks by modeling technological change as an endogenous process. The tradition of modeling technological change as exogenous is understandable when thinking about the Solowian growth model, where TFP is just calculated as a residual without further decomposition. Endogenous technological change allows demand-side shocks to transform into medium-term supply-side deviations in the New Keynesian model, causing changes in potential output growth.

The modern model of endogenous technological change traces back to Romer (1990). Following his intuition, technological progress is modeled as the result of R&D activities done by profit-maximizing firms. If future seems bright, expected future profits are high, and R&D becomes more lucrative, which increases firms' R&D investments, leading to accelerated technological progress. The same process applies the other way around if expectations deteriorate. This intuition is consistent with data: investments and R&D expenditures are highly pro-cyclical (see Figure 5). Therefore, a large negative transitory shock to aggregate demand can slow down technological progress in the long run. Such a relationship is often absent from macroeconomic models. However, it has become more common, and a form of endogenous technological change has been used by Carlin and Soskice (2018), for example.

One of the first attempts to include endogenous technological change into a business cycle model was done by Stadler (1990). Interestingly, he argues that if endogenous technological change is introduced to both a RBC model and a monetary (NK) model, both models exhibit very similar properties to each other, which is not always the case with exogenous technological change.

In a similar fashion, Fatás (2000) uses a simplified model with imperfect competition and aggregate demand externalities to study whether short-term fluctuations affect long-term growth. Aggregate demand externalities means that fluctuations in aggregate demand create externalities on expected profits by firms, whose R&D determines productivity growth, thus also affecting aggregate supply. Quite intuitively, introducing this relationship generates results that short-term demand-side fluctuations can have a persistent effect on long-term growth.

Even though Stadler (1990) and Fatás (2000) produce interesting insights, their models are quite parsimonious. In a more recent paper, Anzoategui, Comin, Gertler, and Martinez (2016) introduce endogenous total factor productivity (TFP) growth to a New Keynesian DSGE model based on Smets and Wouters (2007). This endogenous process has two steps. First, firms create new technologies, thus increasing the stock of existing technologies. This can be interpreted as the traditional R&D activity of firms that includes new product development. Second, the new technologies are adopted by firms with a lag determined by profit-maximizing behavior, which means that not all innovations are adopted right away. Because of this process, there is always a stock of unadopted technologies in the model, from which firms can adopt technologies when it becomes profitable. Thus, TFP growth does not solely depend on innovations but also on the profitability of adoption of these innovations.

In their estimated model, Anzoategui et al. (2016) find that the most important sources of cyclical fluctuations are liquidity demand shocks. These are comparable to risk premium shocks in Smets and Wouters (2007), which can be interpreted as shocks that affect overall uncertainty in the economy. A liquidity demand shock leads to an increased required rate of return by households on risky investments, increasing demand for safe assets and precautionary savings. This has a constraining effect on aggregate demand, and given the process of endogenous technological change, also on TFP growth.

Anzoategui et al. (2016) also find that such a liquidity demand shock is likely to be the reason why the economy moves onto the ZLB. As in other work presented earlier, monetary policy cannot accommodate the shock because of the ZLB, leading to a higher real interest rate than the natural rate. This amplifies the interaction between aggregate demand and endogenous TFP growth, leading to an even larger drop in output in the short run than if ZLB would not bind. Interestingly, Anzoategui et al. (2016) mention in a footnote in page 30 that once the economy enters the ZLB region in the model, it stays there naturally because the natural interest rate remains negative and TFP growth slows down. Unfortunately, the authors do not study this phenomenon further nor do they develop a steady-state equilibrium framework as they focus more on explaining productivity dynamics than business cycles.

To pair endogenous technological change with the theory of permanent liquidity traps and multiple equilibria presented in the previous section, Benigno and Fornaro (2016) develop the concept of a "stagnation trap". They use a classical model of endogenous growth (such as Anzoategui et al. (2016)) with Keynesian features, such as nominal wage rigidities and the ZLB. They find that their model has two steady-state general equilibria, similar to those in Carlin and Soskice (2018). The main difference between Benigno and Fornaro (2016) and the liquidity trap literature presented earlier is that the "bad" equilibrium does not persist because of an arbitrary persistent lack of aggregate demand but because of low productivity growth caused by the shock to demand. In other words, they give a reason why a liquidity trap can become permanent.

In Benigno and Fornaro (2016), the coexistence of a liquidity trap and a "growth trap" can lead to a stagnation trap. A growth trap is caused by the interaction between supply and demand in a recession: low aggregate demand reduces firms' expected profits. This leads to decreased investments in R&D, which leads to a decrease in productivity growth. This leads to a decrease in expected future incomes of workers, which decreases current consumption, thus completing the loop. If the economy is simultaneously in a liquidity trap, the central bank is unable to break the loop by decreasing the real interest rate because of the ZLB. Thus, the economy is stuck in a bad steady-state equilibrium, referred to as a stagnation trap. In this framework, as in the earlier mentioned literature, expectations play a key role in determining which equilibrium path will be chosen and whether the liquidity trap will be permanent or temporary.

An interesting difference between the liquidity traps in Benigno and Fornaro (2016) and permanent liquidity traps in NK models is that in NK models, inflation expectations play a key role in determining the equilibrium path, but in Benigno and Fornaro (2016), they do not. In the latter, the dominating determinant of the equilibrium path is the endogenous growth process because inflation expectations mostly reflect expected productivity growth.

Stepping away from the NK models, another theory how business cycles could affect long-term growth is that the economy might suffer from "hysteresis". As Blanchard and Summers (1986) presented it, there is a possibility that "[short-term] increases in unemployment have a direct impact on the "natural" rate of unemployment" (Blanchard & Summers, 1986, p.15). The intuition is quite simple: if a worker is unemployed for a long time, her skills might deteriorate, and she might choose to exit work force entirely if working opportunities are few and far between. If working opportunities increase in the future, the worker is not as attractive as an employee as before she got unemployed. The same logic applies to capital: if capital is out of use, it begins to rust, and it will become obsolete as time passes, making it a burden for the owner. In addition, the growth trap in Benigno and Fornaro (2016) is a representation of R&D hysteresis, which is quite similar to the above-mentioned hysteresis effects. In all of these cases, a recession could itself decrease output potential in the long run.

Regarding business cycle persistence, the hysteresis hypothesis complements the literature around liquidity traps. Given that the economy is stuck in the bad steady-state equilibrium for an arbitrarily long period, human capital and physical capital will deteriorate. This is likely to reduce aggregate demand, leading to further decrease in the natural interest rate. In this case, liquidity traps are likely to become more common and more persistent. In addition, the hysteresis hypothesis builds a connection between short-term shocks to demand and aggregate supply in the long run as endogenous technological change does: recession might decrease labor, capital and labor productivity semi-permanently and thus hurt long-term growth potential.

Following the hysteresis hypothesis, short-term effects of fiscal consolidation are also capable of transforming to a permanent decrease in potential output. Fatás and Summers (2017) find that the fiscal consolidation caused by increased government debt levels had a large negative effect on long-term performance of GDP and potential GDP estimates. The authors exploit the different levels of fiscal consolidation in different countries to explain the cross-country variation in revisions of potential GDP estimates. Based on their estimations, they find that a higher level of fiscal consolidation results in an increased likelihood of having larger downwards revisions in potential GDP estimates. Regardless of the validity of estimation (omitted variable bias might be relevant), the hysteresis effect is intuitive: decreased government spending during crisis times might have, for example, postponed some public investments that could have contributed to higher potential growth following the crisis.

5.3 Headwinds for long-term economic growth

Long-term economic growth, portrayed by the Solow model ($Y = AK^{\alpha}N^{1-\alpha}$, as formulated in Carlin and Soskice, 2005), is often taken as given: technological progress continuously increases total factor productivity (A) and population growth increases labor force (N). If capital (K) does not decrease, the economy should grow in the long run. The "secular stagnation" hypothesis, which was originally formulated by Alvin Hansen in 1939, argues that the assumption of continuous economic growth is not as certain as often considered. From the viewpoint of this hypothesis, the slow recovery after the financial crisis is mostly a reflection of the decreased long-term growth potential instead of business cycle persistence.

The work on secular stagnation is summarized, for example, in the eBook "Secular Stagnation: Facts, Causes and Cures" (Teulings & Baldwin, 2014), where several authors give their viewpoint on the topic. In the introductory chapter, the editors of the book say that the work on secular stagnation revolves around three pillars, diminished long-term growth potential, persistent GDP gaps and one-off supply-side changes in the level of GDP. The two latter pillars have already been covered in this chapter, but the first pillar has not yet been covered. The pillars are more complements to each other than substitutes: decreased long-term growth potential might decrease natural interest rate permanently, which makes liquidity traps and binding ZLB more frequent phenomena. Nevertheless, this section will review ideas about persistence of low growth caused by a decrease in long-term growth potential independent from business cycles.

If long-term growth potential has decreased, short-term fluctuations and persistence in them seem unimportant in explaining the slow recovery. Secular stagnation implies that the natural real interest rate becomes permanently negative. If this is the case, the economy easily becomes stuck at the ZLB, leading to the "bad" steady-state equilibrium studied in previous sections. However, in many models in the previous sections, the drop in the natural interest rate was caused by a large negative shock, not by long-term changes in any specific factors. Instead of using an arbitrary shock, the literature around secular stagnation attempts to examine how changes in the factors of long-term growth might lead to a permanently negative natural real interest rate.

Gordon (2014) identifies four structural headwinds that have slowed down growth in future potential output. These headwinds are demographics, education, inequality, and government debt. Interestingly, Gordon (2014) argues that these headwinds decrease long-term growth potential even if technological progress continues at the average pace of the four preceding decades. However, it has also been argued that the current industrial revolution caused by the Internet does not have as much potential to enhance productivity growth as earlier industrial revolutions (Gordon, 2012), which further decreases long-term growth potential. In the remainder of this section, I will study these four structural headwinds that might have caused a permanently negative natural real interest rate.

The effects of demographic change caused by lower birth rates and increased life expectancies on economic growth in developed countries are straightforward. Even if population was not decreasing, the growth in labor force might decelerate as fewer workers enter the work force than exit it. This has a direct effect on the labor input (N) in the Solow model. In the past, higher birth rates and increasing participation rates, led by the increase in women's participation, have enabled high growth rates in labor input. If the participation rate cannot increase much further (if there is a "maximum" participation rate) and population growth stagnates, the growth in labor input will be much less in the future than it has been in the past.

Another effect that demographic change has on economic growth is its effect on the natural real interest rate via the supply of savings. Blanchard, Furceri, and Pescatori (2014) list the factors determining the natural real interest rate and try to explain why it has decreased in recent decades. One of these explanations is demographic change: as population ages, the average individual has accumulated more wealth. Therefore, the relative supply of funds increases with demographic change. Ceteris paribus, this decreases the natural real interest rate. In addition to this, Blanchard et al. (2014) find that saving rates have been increasing in emerging markets. These factors promote the idea that the supply of funds has increased, which has further increased the supply of funds in advanced economies, thus having a negative effect on the natural real interest rate.

The second headwind by Gordon (2014) is education. Its effect on growth is somewhat similar to demographic change: in the past, the share of people in a cohort to complete secondary education increased continuously as schooling system became more inclusive worldwide. In addition, the share of people with tertiary degrees increased similarly. If years in education and individual productivity are positively correlated, this growth in education attainment has had a positive effect on growth rates in the past. However, the completion and participation rates in education today are already at high levels in advanced economies, meaning that the productivity-increasing growth in education levels is likely to be lower in the future than in the past.

Inequality, the third headwind, does not have such straightforward implications for long-term growth potential. Yet, according to Gordon (2012, p. 17), it is quantitatively the most important headwind holding down our future income. He achieves this result by comparing the average income growth rate (1.3 %) and the average income growth rate of the bottom 99 % of the income distribution, which was 0.75 % per year. He then deducts the 0.55 % difference from future long-term growth potential, which seems quite confusing.

Regardless of this estimation by Gordon (2012), high inequality has also some direct effects on long-term growth potential. For example, people with smaller incomes are likely to have higher propensities to consume than people with larger incomes. Therefore, concentration of wealth constrains aggregate demand and increases savings, both of which decrease the natural interest rate. In addition, high inequality might hinder social mobility and cause political instability. In the thought experiment of Glaeser (2014), if a large portion of people are unemployed or poor, the democratic process could lead to increasing government transfers and higher taxes, which could further increase unemployment and thus create a negative loop.

The fourth headwind is debt accumulation, especially the accumulation of government debt. According to Gordon (2014), the Congressional Budget Office in the United States has most likely overestimated future GDP growth. This means that if future GDP turns out to be lower than estimated (as Gordon, 2012 also predicts), the debt-to-GDP ratios will increase. Given that many European economies are likely to face problems with fiscal sustainability in the near future, too rosy expectations about long-term growth potential might lead to unexpectedly high debt-to-GDP levels in the future. If this happens, governments are forced to deleverage and cut their spending, which decreases long-term growth potential.

The aim of this section was to identify factors that could indicate that long-term growth potential is decreasing, making secular stagnation possible. Given that the headwinds presented turn out to be significant, advanced economies might become stuck in a situation where the natural interest rates are permanently negative, pushing economies permanently to stagnation steady-state equilibria as in Eggertsson and Mehrotra (2014) or Benigno and Fornaro (2016). Even if this situation does not occur, a decreased natural interest rate might imply that smaller and smaller shocks are able to push the economy to a liquidity trap. However, it is not certain how significant the headwinds turn out to be or whether there will be a large shock that permanently changes long-term growth paths globally.

These shocks can be either positive or negative. As some authors argue (such as Mokyr, 2014), the productivity effects of contemporary innovations might turn out to be significant. If contemporary or future innovations would be able to initiate an industrial revolution, investment demand would increase globally, leading to an increased natural real interest rate. Such large positive technology shocks are mostly unforeseeable, so dooming economies to secular stagnation today involves assuming that such shocks will not be experienced in the future.

Potential negative shocks also contribute to the uncertainty around the secular stagnation hypothesis. After the Great Depression in the 1930s, the shock of World War II led to high economic growth rates and a decrease in inequality. A similar catastrophic shock could lead to long-term economic growth for two reasons. First, the destruction of physical capital would require large post-war investments and rebuilding, which would stimulate economic growth. Second, such a shock could drastically decrease inequality. This point was made, for example, by Thomas Piketty in his book "Capital in the 21st century" (Piketty, 2014). Asset price bubbles could also have similar effects to inequality when capital, the value of bubbly assets, is destroyed.

5.4 Microfoundations and behavioristic agents

The focus of this chapter has mostly been in the analysis of slow recoveries and business cycle persistence in the New Keynesian framework and some recent developments in this framework, such as including the ZLB, financial intermediation and endogenous growth to DSGE models. However, according to Krugman (2018), such major rethinking of macroeconomics has not occurred since the financial crisis, or at least this new thinking has not surfaced to mainstream economics. Following Krugman (2018), this lack of revolutionary ideas has not been caused by widespread incompetence of economics researchers, but it has happened because the contemporary models worked well enough at the height of the crisis.

Despite this lack of major rethinking of macroeconomics, some relatively new developments and revived old ideas (secular stagnation, liquidity traps) have given insights on business cycle persistence. One example of these new developments is the introduction of behavioristic agents and other enriched microfoundations to NK models. This development allows empirically consistent rules for decision-making and forming expectations, which has given insights regarding business cycle persistence.

In NK DSGE models, decision-making by households, firms and policy makers is often modeled as utility-maximizing, optimal behavior. In addition, agents' expectations are often modeled as rational, meaning that decision-makers have full awareness of the underlying economic model and that they take account information of all future periods while making decisions. However, this does not imply that outcomes are always equal to these rational expectations, but the agents' behavior is always rational.

Obviously, this is not a good reflection of the real world, which is a threat to the usability of these models. This rational and forward-looking behavior rarely occurs in the real world. The findings by behavioral economists indicate that people tend to be myopic and irrational, and they have "built-in fallacies", such as the endowment effect. Therefore, modeling expectations and decisions following empirical findings about economic behavior could enrich the model and bring it closer to the real world. This can be done by, for example, limiting or distorting the information available to the agents.

In this section, I will not review the literature of behavioristic agents thoroughly because the literature is so manifold, leading to as many results as there are methods. Instead, I will focus on two selected works (Maćkowiak & Wiederholt, 2015; Gabaix, 2016) to examine how behavioristic modeling affects the outcomes of macroeconomic models, especially regarding business cycle persistence.

Gabaix (2016) leaves the traditional building blocks of the New Keynesian model in place but he introduces a "myopia parameter" to the model. In the context of the model by Christiano et al. (2005) presented earlier in this thesis, the myopia parameter is sort of an additional discount factor to expected household utilities and firm profits, presented in equations 7 and 9. Without further technical details, applying this parameter means that agents are less responsive to shocks and that they underestimate aggregate outcomes of these shocks because they largely ignore changes regarding far future.

Using the underlying mathematics of his model, Gabaix (2016) reaches several conclusions. Among these conclusions, Gabaix (2016) argues that in the behavioral model, the ZLB is less costly than in a rational model. In addition, the behavioral model generates a stable equilibrium even at the ZLB, contrary to the finding of deflationary spirals reviewed earlier in this chapter, but consistent with real-world experiences. Unfortunately, Gabaix (2016) provides little intuition to these findings, except for them originating from agent myopia. However, in addition to the above-mentioned conclusions, this model gives insights on some real-world phenomena that models with rational agents do not model that well, such as the effectivity of forward guidance.

Maćkowiak and Wiederholt (2015) formulate agents' behavior so that obtaining information has a marginal cost. This means that paying more attention to shocks and aggregate variables costs something, forcing agents to optimize how much attention to pay. In their model, all standard features of the NK model are discarded, meaning that the rational inattention becomes the only source of slow adjustment to shocks. The model is able to replicate some of the key results of the NK model, such as the real effects of monetary shocks. Unfortunately, their use of the model does not give many insights on business cycle persistence. However, they formulate an interesting idea about rational inattention and the Great Moderation, the fall on output and inflation volatility between the beginning of 1980s and the financial crisis in 2008.

According to this idea (or thought experiment as the authors formulate it), the Great Moderation happened partly because making monetary policy anti-inflationary affected aggregate attention levels in the economy. Making monetary policy "anti-inflationary" means, according to the authors, that the central bank becomes more aggressive regarding inflation by increasing the inflation coefficient in their monetary policy rule. In a strictly NK model, this change would make nominal and thus real interest more sensitive to shocks, which decreases volatility in the output gap, but increases the volatility in output. However, aggressive monetary policy makes price level (inflation) more stable. Because agents do not pay full attention to the aggregate shocks, the economy becomes more stable from the viewpoint of agents. Because of the apparent stability, agents choose to decrease their attention levels. According to the authors, this effect dominates in their thought experiment with the model, leading to less volatile output as during the Great Moderation.

This idea that agents pay less attention to the economy when it is stable makes it tempting to draw a parallel to Reinhart and Rogoff (2009) and Krugman (2018). In the latter, Krugman (2018) argues that the failure in predicting the financial crisis was not caused by lack of understanding, but more by lack of attention. Economists were aware that "crises triggered by loss of financial confidence do happen, and can be very severe" (Krugman, 2018, p. 158). However, the data about bubbling housing prices and the extended reach of the financial sector were either badly gathered or ignored to some extent. This, and the "this time is different" – syndrome (Reinhart & Rogoff, 2009), can be understood as if they are caused by decreased attention by agents. This idea can also be extended to business cycle persistence: because agents pay little attention, the effect of a large shock might be smaller when agents do not change their decisions all of a sudden.

To conclude, behavioral modeling in DSGE models does not seem to be the most important method in producing results regarding business cycle persistence. However, this modeling can improve the models regarding how they can replicate the real economy and its phenomena. For example, in Gabaix (2016), his model does not produce the rarely occurring explosive deflation at the ZLB as many rational models do. Overall, behavioral modeling can help in getting rid of some paradoxes that theoretical models often have.

6 Policy implications

The literature around business cycle persistence seems to be quite grim by nature. A persistent business cycle is often a synonym for a prolonged recession or a stagnant recovery, not for continuous expansion or extraordinary stability. In the literature reviewed, persistence is caused by the inability of the economy to achieve a real interest rate consistent with full employment, leading to deterioration of long-term growth potential through endogenous responses to gloomy outlooks. Obviously, such scenarios of persistently low output growth, low interest rate, low inflation and high unemployment are undesired by policymakers. Consequently, practically all the articles already cited give some policy recommendations for how to avoid persistent business cycles and secular stagnation.

In this chapter, I will briefly review these recommendations. These policies consist mostly of the traditional economic policies: fiscal and monetary policy. Monetary policy is a particularly interesting topic in the literature because it is part of the problem: the ZLB creates the possibility that the real interest rate deviates persistently from the natural rate. In addition, I present the recommendation of Benigno and Fornaro (2016) to introduce growth policy to accelerate R&D activities counter-cyclically.

6.1 Monetary policy

In theory, liquidity traps occur because monetary policy becomes incapable of generating a real interest equal to the natural interest rate. If a central bank follows an inflation target with an explicit or implicit monetary policy rule (Taylor rule), the rule can suggest a negative policy rate when the natural interest rate is negative and inflation is low (after a recession, for example). As already mentioned in this thesis, this can create a liquidity trap that can have detrimental effects on the economy.

Bluntly speaking, there are two types of policy recommendations regarding monetary policy: unconventional monetary policies in addition to the traditional interest rate policy and rethinking of the traditional interest rate policy. The aim of the former can be seen as to influence the factors of current and future real interest rates in unconventional ways, whereas the aim in the latter is to rethink interest rate rules so that the threat of a liquidity trap is mitigated.

After the financial crisis, central banks have employed unconventional monetary policies that tackle the problem of inefficient interest rate policy. These include, for example, quantitative easing (QE) and forward guidance. QE is a policy tool that consists of the central bank buying assets from commercial banks (see European Central Bank, 2018). The ECB, who has executed this quantitative easing in recent years, describes the effect of QE as follows. First, buying assets (bonds) from commercial banks increases the price of these assets and thus creates money in the banking system. When banks have more money to borrow, the supply of loanable funds increases, which decreases interest rates, making loans cheaper. This leads to a boost in consumption and investments, which stimulates economic growth.

QE affects both the actual real interest rate and the natural interest rate. Given that the new money in commercial banks actually enters the real economy, the money injection is likely to lead to higher inflation as prices and wages adjust to the increased amount of money in circulation. In addition, increased supply of loanable funds puts a downward pressure on nominal interest rates as mentioned above. Both of these effects can decrease the real interest rate.

Central banks have also used forward guidance as an unconventional policy tool recently. Even though forward guidance is maybe not seen as "unconventional" as in the past, it is indeed a policy tool to use when interest rate policy becomes ineffective. The aim of forward guidance is to influence expectations regarding future monetary policy by communication. As earlier discussed in this thesis, expectations have significant effects on real outcomes, implying that influencing these expectations might have real effects. Forward guidance works through two channels. First, it influences the actual expectations of future inflation and interest rates. For example, the central bank might say that it will have a zero policy rate for a prolonged period, which affects expected levels of inflation. Second, forward guidance decreases uncertainty around monetary policy. For example, the central bank might give medium-term projections of its future policy rates. The effect through both of these channels depend on the credibility of the central bank. If the central bank's commitment seems credible to agents, agents will consider the new information when forming their expectations, otherwise not that much.

When the economy is in a liquidity trap, Krugman (1998) notes that credibility of the central bank plays a key role in determining the efficiency of central bank's policies overall. In his model, only permanent monetary expansions are effective increasing inflation. However, the permanent expansion becomes ineffective if people believe that the central bank will revert to its price-stabilizing policy when given the chance, making the alleged permanent expansion only temporary. Therefore, when the credibility of the central bank is low, people consider the alleged permanent expansion to be only temporary, meaning that the intended permanent expansion has only the effect of a temporary one.

Even though the unconventional monetary policies can improve central banks' efficiency in stabilizing the economy, some authors have also focused on improving conventional interest rate policies. These improvements include, for example, making central banks' interest rate policy more aggressive and increasing inflation targets. The former consists of suggestions to modify interest rate rules so that interest rate policy becomes highly aggressive when a threat of a liquidity trap arises, and the latter consists of increasing current inflation targets to make it easier to have negative real interest rates when there is a threat of a liquidity trap.

Benhabib, Schmitt-Grohé, and Uribe (2002) suggest that when the economy is falling into a deflationary spiral, the central bank could shift from inflation targeting to targeting only the growth rate of money. After this shift, the central bank would let markets determine interest rates. However, according to the authors, this approach is not feasible when fiscal policy is "Ricardian", which means that government deficits react to public debt so that the long-term solvency of the government is always secured. However, the authors are able to show in their model that when fiscal policy is non-Ricardian, the aforementioned change in monetary policy regime can rule out a liquidity trap. Unfortunately, their analysis seems quite technical and model-specific, raising concerns about the feasibility of the regime change.

Evans et al. (2008) suggest an interest rate rule where there is an ordinary global interest rate rule for inflation rates above a predetermined inflation threshold (which is lower than the inflation target). When the inflation rate drops below this threshold, central bank sets its interest rate immediately to a predetermined level close to zero. The interest rate will stay at this level until inflation is above the predetermined threshold. The authors call this an aggressive monetary policy as opposed to normal monetary policy that follows an ordinary interest rate rule. In fact, it seems that the Federal Reserve in the United States and Bank of England executed this kind of monetary policy after the financial crisis, at least compared to the ECB (see Figure 11).

Following the discussion of Krugman (1998), Eggertsson and Krugman (2012) argue that in order to have negative real interest rates, there has to be expected inflation. If the economy is in a liquidity trap, deflation would "work" in creating expected inflation: a decrease in today's price level relative to expected future price level creates expected inflation. However, if the central bank exercises inflation targeting and not price level targeting, such deflation would not be desired because of the large deviation from the inflation target.

In their model, higher expected inflation without experiencing deflation could be achieved by increasing the inflation target. However, as earlier discussed, the effectiveness of increasing the inflation target depends on the credibility of the central bank. The credibility in this case might be low because “central bankers normally see themselves as defenders against rather than promoters of inflation –“ (Krugman, 1998, p. 1489).

In their model of secular stagnation, Eggertsson and Mehrotra (2014) also experiment with the idea of increasing the inflation target, taking the credibility of the central bank as given. In their graphical framework presented in Figure 15, the increase in inflation target shifts the kink in the AD' curve upwards in a way that the upwards-sloping part of the AD' curve stays the same while the downwards-sloping part shifts to the right. If the kink is shifted enough to the right, there will be three equilibria: two full-employment equilibria around the kink and the secular stagnation equilibrium. The key intuition in this analysis is that increasing the inflation target does not remove the secular stagnation equilibrium even if it does enable the full-employment equilibrium.

Similarly to Evans et al. (2008), Benigno and Fornaro (2016) suggest an interest rate rule where, when the nominal interest rate drops to zero, the interest rate is pegged to a predetermined value for the following period, after which monetary policy continues to follow an interest rate rule. The authors argue that, given the central bank's ability to commit, formulating monetary policy this way eliminates the threat of a stagnation trap because the trap would require a protracted period of zero interest rates. The protraction becomes impossible in their formula (Benigno & Fornaro, 2016, p. 31) because the interest rate can be zero for only one period at a time. The authors argue that commitment plays a large role in avoiding stagnation trap because, in their example, a central bank that exercises discretion (optimizes every period) is unable to prevent a stagnation trap.

6.2 Fiscal policy

When traditional monetary policy becomes ineffective, fiscal policy becomes the only tool for stabilizing economic growth. Fiscal policy has both a direct effect on aggregate demand and an indirect effect via the fiscal multiplier. However, when deciding upon fiscal policy, governments face a trade-off between stimulating aggregate demand and increasing government debt. If governments are unwilling to increase public deficits in a recession, the consequent lack of aggregate demand might severely slow down the recovery phase.

To put it bluntly, governments can execute fiscal stimulus in two ways: by cutting taxes or by increasing spending. Both of these individually are likely to lead to an increased public deficit and debt. However, there is no consensus in which of this methods is more efficient in stimulating growth. Many European economies resorted to fiscal consolidation (Alesina, Barbiero, Favero, Giavazzi, & Paradisi, 2015) when facing increasing and possibly unstable public debt levels. As Fatás and Summers (2017) argue, this is likely to have had a large negative effect on long-term growth potential in many countries.

According to Krugman (1998), if the economy is in a liquidity trap, fiscal expansion is the "classic Keynesian answer". However, he is not able to quantify this answer in his model where Ricardian equivalence holds (consumers internalize government budget to individual budgets; fiscal policies have no effect on consumption). Regardless of that, he contemplates the idea that if marginal propensity to consume is large, multiple equilibria might exist. In his words, this means that a sufficiently large fiscal expansion could push the economy out of the liquidity trap.

In their recommended policy mix for avoiding liquidity traps, Evans et al. (2008) argue that fiscal policy can be used to set lower bound for inflation. Using aggressive monetary policy, which means that the interest rate is dropped almost to zero when inflation seems to fall below a determined positive threshold, fiscal policy serves only an assisting role in sustaining inflation when monetary policy has to become aggressive as described. Using this policy mix, the authors are able to model a single and stable steady-state equilibrium.

In Eggertsson and Mehrotra (2014), fiscal policy plays a large role in pushing the economy out of the secular stagnation equilibrium. Interestingly, the authors find that increasing public debt permanently increases the natural interest rate because the overall demand for loans increases. They also find that debt-financed public spending can eliminate the secular stagnation steady-state equilibrium in their AS-AD framework presented earlier in Figure 15. It can be seen that shifting the AD' curve right with increased public spending eventually leaves only one possible steady-state equilibrium.

6.3 Growth policy

The aim of monetary and fiscal policy is primarily to stabilize the economy from short-term fluctuations. In this regard, these traditional policies seem sufficient. However, the effect of monetary and fiscal policy on long-term growth potential is less straightforward. For example, Duval and Obstfeld (2018) argue that accommodative monetary policy might have negative effects on productivity growth under some circumstances (in addition to the positive effects). They present their argument in more detail but their underlying logic is that when the terms of lending are eased, less profitable investments become profitable. Given that imperfections in financial markets exist, the firms that are not credit-constrained are able to expand their borrowing more than credit-constrained firms. This creates dispersion in the marginal product of capital, meaning that firms that are able to obtain cheap financing invest more and more in projects of deteriorating quality, having potentially a negative effect on productivity growth.

A straightforward way to stimulate long-term growth potential is to influence the factors of the Solow growth model directly. This kind of action can be already seen in countries with adverse demographics who are encouraging immigration to prevent the labor force from shrinking. In addition, many countries have managed to increase participation rates in the 2000s. Increasing the amount of capital in the economy is a more difficult question as many new firms, especially in the digital sector, do not rely on physical capital in their businesses. The ongoing wave of digitalization can also decrease the amount of capital needed as the economy becomes more efficient.

Therefore, the focus shifts to enhancing productivity growth. In fact, the deceleration of technological progress in an economic downturn is one of the factors that lead to a stagnation trap in the study by Benigno and Fornaro (2016). In their model, weak demand limits firms' incentives for R&D. The authors argue that a helpful tool for this problem is R&D subsidies. They find that these subsidies could work as a countercyclical policy tool because productivity growth enhances economic growth and thus also employment and aggregate demand. They also find that introducing these R&D subsidies can eliminate the stagnation trap equilibrium. This result of course depends on the marginal efficiency of R&D: it might be that even if government would introduce high R&D subsidies, there might not be enough fruitful R&D projects to invest in.

There is also alternative ways to enhance productivity growth. For example, governments could invest more in education and thus increase human capital, or governments could accelerate the progress of creative destruction by reforming laws on bankruptcy and entrepreneurship. In addition, governments could focus on decreasing inequality and empower poor citizens economically. Thus, the list of growth-enhancing reforms is long and it varies between countries.

7 Conclusions and discussion

Despite the lack of major rethinking in macroeconomics after the financial crisis, economists have been able to explain persistence in business cycles with contemporary theory and models at least partly. There have been several different ideas but not really a consensus view on the slow recovery. Business cycle persistence might either reflect the overall inability to adapt to a shock, the effects that short-term fluctuations have on long-term growth potential, the overall decrease in factors of long-term growth, or some combination of these three.

After the turn of the millennium, increasing attention has been paid to the effects of short-term fluctuations in economic activity on long-term economic growth. This attention increased even further with the financial crisis. Findings from empirical research seem to indicate that short-term fluctuations do in fact affect long-term growth potential. Therefore, the assumption that economic growth follows a deterministic growth trend seems to be invalid.

The relationship between short-term fluctuations and long-term growth potential seems to be vaguely defined in contemporary economics, as the two phenomena have been considered independent in the past. The phenomena have also often been defined so that short-term fluctuations stem from high-frequency demand-side shocks, whereas changes in long-term growth potential occur because of low-frequency supply-side shocks. Assuming that this definition is valid, understanding business cycle persistence requires some link between the demand side and the supply side fluctuations in an economy.

In the short run, the post-shock adjustment of the economy as a whole might be distorted if the economy falls into a liquidity trap. This might occur if the shock leads to a drop in the natural interest rate below zero and if inflation is simultaneously low.

In this case, monetary policy becomes constrained by the ZLB because the central bank does not want to have negative nominal interest rates in the fear that people would resort to cash as an asset. Therefore, it is likely that the natural interest rate will not be achieved with monetary policy. This prevents the economy from adjusting to the shock in a way that the underlying economic model would imply, leading to persistence in the economic downswing.

In the literature reviewed, it is possible that a liquidity trap becomes a permanent phenomenon. The fact that monetary policy is active around the inflation target but becomes passive at the ZLB might lead to multiple equilibria in an economy. Usually this means two steady states: one consistent with the inflation target and full employment, and the other consistent with a liquidity trap, zero interest rate, low growth, low inflation, and high unemployment. The shift from a "good" steady-state equilibrium to a "bad" one can be caused by a large enough negative shock to expectations.

The severity of the ZLB constraint depends on how agents' expectations are modeled. If agents have rational expectations, meaning that they react sharply to any new information, the ZLB constraint is severe. If agents adjust their expectations drastically downwards after a shock (knowing that ZLB binds), the future expectations of low inflation or deflation might be self-fulfilling. However, if agents have limited information or imperfect decision-making capability, the expectations might not change so drastically after a shock, leading to alleviated severity of the ZLB.

The theory of endogenous technological change is useful in understanding the effects of short-term fluctuations on long-term growth potential. The models that use endogenous technological change build a relationship between R&D activity done by firms and aggregate productivity growth. In such a model, productivity growth is a result of profit-seeking R&D activities by firms. If aggregate demand suddenly decreases, the expected profits of firms decrease, which makes R&D less profitable. Therefore, a recession leads to decreased productivity growth. This endogenous relationship can be seen in real-world data: R&D activity and capital accumulation are highly pro-cyclical.

The combination of the ZLB and endogenous technological change is effective in explaining business cycle persistence. This phenomenon of being simultaneously in a liquidity trap because of the ZLB and in a growth trap because of low R&D activity is called a "stagnation trap" (Benigno & Fornaro, 2016). In a stagnation trap, the liquidity trap pulls economic activity down, which makes firms decrease their R&D activity, leading to a decrease in long-term growth potential. The economy becomes stuck in a low growth, high unemployment steady-state equilibrium as the two forces generate a negative loop. Therefore, in this framework, a recession caused by a short-term shock can become persistent.

Another interesting explanation in the literature explaining the slow recovery is secular stagnation, the expected drop in future growth potential regardless of short-term fluctuations. According to the secular stagnation hypothesis, some ongoing developments in economic variables can make the natural interest rate negative permanently. These developments are, for example, adverse demographics, excess savings, and decreased marginal product of innovations. If the natural interest rate does not experience a positive shock in advanced economies, a permanently negative natural interest right might make liquidity traps and recessions more frequently occurring events.

The simplest way out of a "bad" steady-state equilibrium would be a large fiscal stimulus that would keep aggregate demand in a sufficiently high level. However, as governments have faced increasing debt-to-GDP ratios recently, such large-scale stimuli have not been used as widely as possible in accelerating the recovery. Regarding endogenous technological change, R&D subsidies might alleviate the threat of falling into a stagnation trap because productivity growth leads to economic growth and thus to increased aggregate demand. In addition, central banks can exercise unconventional monetary policies, such as quantitative easing, in order to match real interest rate with the underlying natural rate. Another solution would be to increase the inflation targets, but the effect of that depends on the credibility of the central bank's commitment to high inflation in the future. High inflation also brings costs of its own, casting doubts on the credibility of commitment to higher target inflation.

The literature review in this thesis also raised some questions that, in my opinion, were not addressed in depth. First, the treatment of shocks in models left me thinking whether shocks could be interpreted more as endogenous, cyclical processes instead of just random shocks. After all, the financial crisis did not occur at random (even though the time could have been somewhat random) as it was caused by new information on problems in the financial sector, which led to a negative shock to expectations that were originally high because of accumulated optimism during the boom. This raises the question whether one key driver of the crisis was inattention. An interesting thought experiment regarding "rational inattention" and the Great Moderation has been done by Maćkowiak and Wiederholt (2015), which gives some ideas how business cycles could also be caused by inattention.

Finally, this thesis has not put much weight on supply-side shocks that could affect business cycle persistence in a certain country or geographical area. The reason why supply-side shocks have not been emphasized that much is that they are usually considered to have a direct effect on long-term growth potential. Therefore, there would be less interest in studying the persistent effects of supply-side shocks because they are persistent by nature. In addition, the supply side does not usually experience high frequency fluctuations as the demand side does, meaning that they do not account as much as demand-side shocks do for short-term fluctuations in output.

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A Appendix to data

Country groups	
PIGS	Portugal, Italy, Greece, Spain
Core	Belgium, France, Germany, Luxembourg, Netherlands
Other Eurozone	Austria, Croatia, Cyprus, Estonia, Finland, Ireland, Latvia, Lithuania, Malta, Slovenia
Non-Eurozone	Bulgaria, Czech Republic, Denmark, Hungary, Norway, Poland, Romania, Sweden, Switzerland, United Kingdom

AMECO:
https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco_en
Eurostat:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=namq_10_gdp&lang=en
U.S. Bureau of Economic Analysis:
https://www.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=3&isuri=1&1921=survey&1903=6
OECD:

https://data.oecd.org/gga/general-government-debt.htm
Bank for International Settlements (BIS):
https://www.bis.org/statistics/cbpol.htm

Variable	**Source**	**Code**
Gap between actual and potential gross domestic product at 2010 reference levels	AMECO	AVGDGP
Unemployment rate, %	AMECO	ZUTN
Real short-term interest rates, deflator GDP	AMECO	ISRV
Nominal short-term interest rates	AMECO	ISN
Price deflator gross domestic product	AMECO	PVGD
Potential gross domestic product at 2010 reference levels	AMECO	OVGDP
Gross domestic product at 2010 reference levels	AMECO	OVGD
Private final consumption expenditure at 2010 prices	AMECO	OCPH
Final consumption expenditure of general government at 2010 prices	AMECO	OCTG
Gross capital formation at 2010 prices: total economy	AMECO	OITT
GDP, Chain linked volumes (2010), million euros	Eurostat	namq_10_gdp
Real Gross Domestic Product, Chained Dollars	bea.gov	
General government debt, total, % of GDP	OECD	
Central bank policy rates	BIS	BIS_CBPOL (M:US, M:GB, M:XM)